Technical Study 57e

Effects of Decreasing Fertility on Infant Mortality Levels

Erica Taucher

Infant Mortality and Health Studies

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Abstract

This document is directed to future researchers on the effects of fertility rate upon infant mortality. The results of these studies can serve to guide activities in maternity and infant care and family planning programs.

The author's experience in a number of studies based on data from Latin American countries is presented. An account is given of how the research objectives originated and what procedures were used to analyze infant mortality differentials, as well as a description of the adaptation of reproductive behaviour to the economic situation and of the nature of infant mortality differentials measured by variables related to the fertility rate. The results show that a high fertility rate, short intervals between successive births, and the age of the mother, at either extreme of the child-bearing span, are all factors that increase the risk of infant mortality. As fertility rate decreases, the number of such births declines and this favours a lower infant mortality. Despite some contradictory results, there are indications that the differentials are biological in nature.

Among the various problems encountered, those having to do with sources and the quality of data are analyzed. There follow proposals for techniques to measure the effects of a decrease in the fertility rate upon infant mortality. The work closes with a list of objectives for future research on fertility and infant mortality.

Résumé

Cette publication est destinée aux personnes qui étudieront éventuellement l'effet du taux de fécondité sur la mortalité infantile. Les résultats des études exposés dans cette publication pourraient servir à orienter les programmes de soins maternels et infantiles et de planning familial.

L'auteure présente son expérience dans la réalisation d'études fondées sur des données de pays latino-américains. Elle dit comment ont été déterminés les objectifs des études et quelles méthodes d'analyse ont été appliquées aux données sur les différences de mortalité infantile, et parle de l'adaptation du comportement reproductif à la situation économique et de la nature des différences de mortalité infantile mesurée par des variables reliées au taux de fécondité. Les résultats montrent que le nombre élevé des naissances, les intervalles intergésiques courts et l'âge des mères aux deux extrémités de leur vie féconde sont des facteurs qui augmentent les risques de mortalité infantile. La réduction de la fécondité fait baisser la proportion des naissances présentant ces caractéristiques, ce qui favorise la réduction de la mortalité infantile. Il y a lieu de croire que ces différences de mortalité infantile sont de nature biologique malgré quelques résultats contradictoires.

Au nombre des problèmes rencontrés, l'auteure a analysé ceux se rapportant aux sources et à la qualité des données. L'auteure propose ensuite quelques techniques pour mesurer l'effet de la réduction de la fécondité sur la mortalité infantile et conclut par l'énumération de quelques objectifs à donner aux futures études de la fécondité et de la mortalité infantile.

Resumen

El documento está dirigido a futuros investigadores del efecto de los niveles de fecundidad sobre la mortalidad infantil. Resultados de esos estudios servirían para orientar las acciones de los programas de atención materno-infantil y de planificación de la familia.

Se presenta la experiencia de la autora en algunos estudios con datos de países de América Latina. Se relata cómo se originaron los objetivos de las investigaciones y los procedimientos de análisis utilizados para llegar a los resultados sobre diferenciales de mortalidad infantil, adaptación de la conducta reproductiva a las contingencias económicas y naturaleza de los diferenciales de mortalidad infantil por variables relacionadas con el nivel de la fecundidad. Los resultados muestran que alto orden de nacimiento, intervalos intergenésicos previos cortos y edades maternas en ambos extremos de la edad fértil constituyen factores que elevan el riesgo de mortalidad infantil. Al descender la fecundidad disminuye la proporción de nacimientos con tales características, lo que favorece el descenso de la mortalidad infantil. Hay indicios de que aquellos diferenciales son de naturaleza biológica a pesar de algunos resultados contradictorios.

Entre los distintos problemas que se encontraron, se analizan los referentes a las fuentes y a la calidad de los datos. A continuación se proponen algunas técnicas para medir el efecto del descenso de la fecundidad en la mortalidad infantil y se concluye con la enumeración de algunos objetivos que podrían tener futuras investigaciones de fecundidad y mortalidad infantil.

CONTENTS

FOREWORD

The Population, Health, and Development (PHD) project of the International Development Research Centre's Social Sciences Division was created in 1983 as a temporary mechanism to support and strengthen the capacity of developing-country researchers to carry out interdisciplinary investigations of the persistent problems of high levels of infant and child mortality and poor health. To this end, with the active involvement of the Health Sciences Division, the project has organized a number of activities. These include a series of interdisciplinary regional workshops in Latin America and Africa for health and social scientists; preparation of two research bibliographies; and sponsorship of researchers to international conferences.

In addition, the PHD project commissioned a series of technical research papers on widely recognized problems or gaps in infant mortality research. These papers were reviewed by peers and published in the IDRC Infant Mortality and Health Studies Series. They address specific methodological and conceptual issues in the research, data sources, and collection and analysis of data.

It should be noted that these studies are not intended to be based exclusively on original or primary data. Rather, they are meant to examine and update research on specific methodological problems. The authors are researchers whose work successfully integrates conceptual and methodological approaches both from the health science and from the social science research traditions. Where appropriate, a field-manual style was encouraged. Otherwise, an operational and illustrative approach was used in preparing the papers for publication.

Effects of Decreasing Fertility on Infant Mortality Levels illustrates procedures that can be used to evaluate the impact of fertility decline and the structure of this decline on infant and child mortality levels. The case studies are from Chile, Costa Rica, Mexico, Paraguay, and Peru. The monograph illustrates both methodologically and substantively that fertility and maternal factors affect mortality risk. The case studies will also have significant policy implications for planners and providers of family planning and maternal-child health services. The author, Erica Taucher, a Doctor of Medicine with a Master's degree in mathematical statistics, is a Public Health Investigator at the University of Chile.

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INTRODUCTION

When fertility and infant mortality are studied in different geographical areas or over time, a close, direct link is usually found to exist between these two variables, partly because certain factors, such as the degree of urbanization or level of education, act in the same direction on the two indexes.

Infant mortality and fertility also have reciprocal relations, however, that are independent of these common or interconnected determining factors. Thus, high infant mortality can act as an obstacle to decreasing birth rate. Conversely, high fertility can create unfavourable conditions for infant survival.

It appears, for example, that the effect of infant mortality on fertility begins to be felt only when infant mortality has dropped to levels low enough to assure couples that the children born to them will survive. High infant mortality also shortens the period of natural sterility associated with lactation. In populations that do not practise birth control, this can contribute to a higher number of births during a woman's child-bearing years by shortening the intervals between pregnancies. Another reason that fertility remains at high levels when infant mortality is high may be the wish to replace a dead child. These factors were all considered in examining the difficulties family-planning programs have had in achieving drops in fertility (Rutstein and Mĕdica 1975; Chowdhury et al. 1976; Taylor et al. 1976; Cochran et al. 1983).

There are also links between infant mortality and fertility that work in an inverse direction; these will be studied here. Many studies have shown that major infant mortality differentials exist with regard to at least three variables related to fertility: birth order, mother's age, and the length of the interval between successive births (Puffer and Serrano 1973; Vavra and Querec 1973; Nortman 1974; Wolfers and Scrimshaw 1975; Taucher 1979a,b, 1985). All the studies note that infant mortality increases with birth order, and that it is higher when the mother is at the upper or lower end of the child-bearing span or when the interval between two successive births is very short. The proportion of births that occur under these adverse conditions is higher when fertility levels are high. Therefore, if a drop in the fertility rate can cause a shift toward fewer births, more suitable mothers' ages, and longer intervals between successive births, infant mortality would be reduced. For this reason, reducing infant mortality should be among the objectives of many family planning programs, especially in Latin America.

Nonetheless, when interpreting the impact of a drop in the fertility rate on infant mortality, the nature of the differentials mentioned above must be studied because this relates directly to policies and actions to regulate the fertility rate.

One possibility is that the differentials may be mainly of socioeconomic origin, caused by a higher proportion of births at lower social strata in the higher risk categories. If this is true, a policy of regulating fertility aimed at having fewer children in the middle of the child-bearing span and spacing them at adequate intervals would not have a great deal of impact on the infant mortality rate.

On the other hand, some research findings indicate that infant mortality differentials caused by these variables are due to the fact that women who are exhausted by many pregnancies at short intervals and at older ages, or women who become pregnant when too young and immature, bear children with less biological potential for survival. If this is true, family planning would make sense to ensure that children are born when women are in the best condition for maternity, regardless of their social stratum.

An awareness of the factors that imply the greatest risk of infant mortality will also make it possible to develop criteria for special benefits or increased health care for children and pregnant women belonging to these groups.

The above indicates that research on the effects of fertility on infant mortality can contribute results that will be useful in guiding the actions of mother-child care and family-planning programs.

I hope that this presentation of the experience and results I obtained in studies of Latin American countries will be useful to researchers, first, for defining the goals of their research and, second, by offering solutions to some problems they may encounter during their work. Special emphasis will be placed on problems related to the existence, integrity, and quality of the necessary data. Analysis methods that have served to quantify the impact of a decline in fertility on infant mortality will also be presented. Finally, some areas for future research will be proposed because they may be of interest to a particular country or because they bear on questions that have not been addressed in current research.

CHAPTER 1: EXPERIENCE GAINED FROM SOME STUDIES USING DATA FROM LATIN AMERICAN COUNTRIES

Objectives

The first study presented here (Taucher 1979a) originated in a desire to find an explanation for the continuing decline in infant mortality in Chile. The drop began in 1960 and was not interrupted by the periods of economic decline that the country suffered later. This perplexed those who had always viewed infant mortality as an indicator sensitive to changes in the standard of living. Among the hypotheses explored in the study, which included the impact of the mother-infant and supplementary-food programs that were already traditional, it was postulated that the decline in the fertility rate observed after 1964 could have made a significant contribution to this unexpected behaviour in the infant mortality rate. While the infant mortality rate dropped from 96 to 66 per 1000 from 1965 to 1972, the crude birth rate dropped over the same period from 36.3 to 28.6 per 1000. It was assumed that this drop in fertility would cause the birth structure to move toward a higher proportion of infants whose risk of dying was low, which would contribute to a reduction in the infant mortality rate.

Some of the results from this study confirmed the characteristics of infant mortality differentials related to the fertility rate found by other investigators. Questions also arose regarding the biological or socioeconomic nature of these differentials. This prompted another study, now extended to four Latin American countries in addition to Chile (Taucher 1982a,b). On one hand, the aim was to quantify the effect of changes in birth structure on infant mortality levels. On the other, an attempt was made to explore the nature of the differentials under study.

From a discussion of earlier works, the idea arose that a different explanation for the continuing decline in infant mortality in Chile might be that reproductive behaviour adapts to economic contingencies. If, during an economic crisis, births occur predominantly in families not affected by it, a downturn in the economy would not necessarily have to translate into an increase in the infant mortality rate. This is related to explanations that seek to show that changes in birth structure cause infant mortality to behave independently of the economic situation. A preliminary study showed that, contrary to the case with infant mortality, trends in fertility levels and economic indicators are closely correlated. This merits completing the study of this hypothesis in the future using a different methodological approach.

Infant Mortality Differentials and the Impact of Changes in Birth Structure on Infant Mortality Levels

To explore the hypothesis that a drop in fertility was a contributing factor to the sustained drop in the infant mortality rate in Chile, the first of the studies mentioned (Taucher 1979a,b) used vital statistics from the cohort of births in 1972, birth statistics in 1972, and death statistics in 1972 and 1973, provided by the Instituto Nacional de Estadísticas y Censos (National Institute of Statistics and Censuses).

By making crossed classifications of both births and deaths of children under 1 year by mother's age, birth order, mother's schooling, and father's occupation - data that are recorded for both events - it was possible to construct specific rates and observe differences in infant mortality based on these variables, both isolated and combined.

The expected differentials were found: rising infant mortality with birth order and U-curves for the mother's age, showing that infants of very young and overly mature women run a higher risk; patterns that continue to hold for each variable within the categories of the other (Fig. 1; Tables 1, 2, and 3). The risk was higher in all birth orders if the child had a father in a low income category or a mother with a low level of education (Taucher 1979b).

With regard to the hypothesis that gave rise to the study, using a method that will be explained in chapter 4, it was estimated that 13% of the total decline in infant mortality from 1965 to 1972 can be attributed to changes in the structure of birth order and age of the mother (Taucher 1979a). The decrease in the number of births in order 4 or higher from 43% in 1965 to 29% in 1972, which is an indication of a shift in birth structure toward orders with lower risk of infant mortality, explains 11% of the decline in the infant mortality rate. The favourable impact of the drop in the number of children born to women 35 years of age and over, from 18% in 1965 to 12% in 1972, was counteracted by an increase in the number of children born to women under 20 years of age, from 12% in 1965 to 16% in 1972. Thus, the impact of changes in structure caused by the mother's age on the infant mortality rate was virtually nil. If the combined changes caused by birth order and mother's age can explain 13% of the total decline in the rate, this indicates that the effect of the changes is not additive; on the contrary, an interaction occurs that makes the joint influence of both changes more favourable than the sum of their isolated effects.

Data from fertility surveys conducted in some countries under the World Fertility Survey Program in the late 1970s made it possible to extend the study on infant mortality differentials based on variables related to fertility to cover Costa Rica, Mexico, Paraguay, and Peru (Taucher 1982a). To contrast countries with different fertility levels, these four countries were selected from those for which standardized statistics were made available from the World Fertility Survey to the Latin American Demographic Center (CELADE).[1] The

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[1]This study by CELADE was made possible thanks to financial support from the Ford and Rockefeller Foundations.

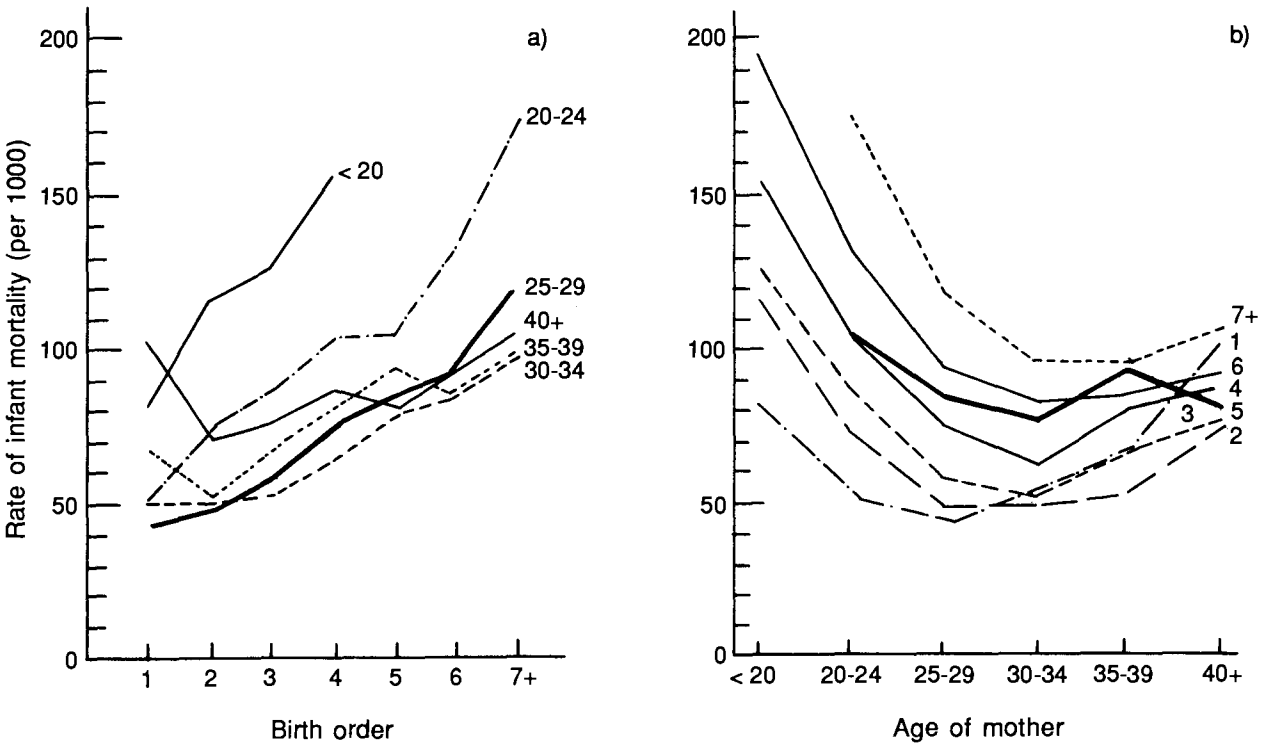

Fig. 1. Specific infant mortality rates, Chile 1972. (a) By birth order within mother's age groups. (b) By mother's age within birth order groups.

Table 1. Neonatal mortality rates (per 1000) by birth order and by mother's age and education, Chile 1972.

Mother's age and level of education	Birth order							
	Total	1	2	3	4	5	6	7 +
Total	31.70	28.88	30.43	30.07	33.32	35.51	38.31	40.20
Under 20	38.62	33.76	48.50	48.74	69.14	61.13	64.13	-
20-24	29.70	26.02	29.87	31.08	37.10	36.43	49.70	65.17
25-29	26.49	22.91	22.21	25.98	27.49	34.41	36.13	41.13
30-34	29.62	29.98	27.67	25.62	28.21	31.39	33.29	32.88
35-39	40.04	38.65	28.90	37.00	41.83	46.75	40.56	42.25
40 and over	43.18	57.31	28.39	36.15	50.89	28.54	47.58	44.40
None	56.53	73.99	67.01	56.52	51.77	48.51	48.93	48.53
Under 20	72.64	70.67	67.59	94.55	82.28	45.43	218.04	-
20-24	62.27	75.10	78.15	42.05	51.43	54.51	68.56	35.45
25-29	50.37	66.70	65.67	49.90	44.27	31.09	49.44	50.99
30-34	51.50	109.94	60.77	71.44	44.93	51.65	31.92	43.66
35-39	59.44	63.59	8.72	76.51	89.78	92.06	52.54	54.74
40 and over	47.54	62.65	68.14	27.95	39.89	22.48	68.14	46.82
Primary or basic	31.94	30.79	31.82	29.73	30.82	33.70	35.92	36.57
Under 20	38.32	34.36	46.17	43.12	61.03	69.88	-	-
20-24	30.00	27.47	29.70	29.82	34.61	31.30	47.52	69.13
25-29	27.90	26.68	23.62	26.68	26.20	34.11	33.77	37.29
30-34	28.38	29.05	31.31	24.52	24.48	29.59	32.24	28.64
35-39	37.27	40.78	32.61	36.31	34.52	43.20	38.53	36.83
40 and over	43.42	58.03	27.68	42.80	57.06	31.43	40.30	43.86
Secondary or higher	24.62	21.36	23.20	25.41	35.24	34.61	42.13	61.04
Under 20	31.79	25.51	54.14	58.14	161.51	-	-	-
20-24	24.18	20.88	24.42	33.10	43.54	62.13	22.71	172.13
25-29	19.50	16.21	17.50	21.16	26.02	40.30	36.69	72.20
30-34	24.50	22.60	18.89	20.60	33.35	26.50	44.20	54.67
35-39	36.34	30.90	25.25	29.54	46.04	30.57	39.14	72.28
40 and over	35.62	53.54	12.38	24.55	38.74	21.80	61.71	40.08

Source: Instituto Nacional de Estadísticas y Censos.

Table 2. Post-neonatal mortality rates (per 1000) by birth order and by mother's age and education, Chile 1972

Mother's age and level of education	Birth order							
	Total	1	2	3	4	5	6	7 +
Total	42.82	33.19	39.99	43.44	49.79	52.60	54.76	64.15
Under 20	55.95	49.01	68.78	79.12	86.61	41.39	130.26	246.04
20-24	42.61	27.20	44.33	56.89	66.93	68.06	85.26	110.32
25-29	35.56	21.13	26.25	33.30	48.00	51.14	57.45	78.60
30-34	38.17	22.74	22.38	27.39	36.14	47.10	50.03	63.82
35-39	43.57	29.95	24.46	31.48	38.49	46.91	44.94	56.66
40 and over	53.70	46.30	44.69	40.96	36.73	53.84	45.56	61.22
None	96.35	107.15	113.19	100.68	116.09	99.13	78.97	93.96
Under 20	125.82	133.02	128.44	79.09	167.12	46.14	-	-
20-24	109.97	99.15	110.59	98.07	146.24	83.04	97.49	180.03
25-29	91.20	53.72	117.84	101.37	82.43	94.74	72.81	107.14
30-34	83.51	102.35	65.35	88.32	82.13	88.36	84.79	81.87
35-39	89.53	46.14	53.15	103.60	149.79	103.34	75.59	88.02
40 and over	86.35	63.63	138.40	99.36	94.52	148.39	25.95	84.80
Primary or basic	46.99	42.51	49.32	50.52	51.06	51.67	56.33	60.03
Under 20	58.43	52.38	67.93	79.17	78.89	42.58	201.31	138.40
20-24	47.94	33.65	49.58	58.65	59.76	66.22	82.33	91.82
25-29	42.24	31.58	35.62	37.90	47.48	47.47	56.45	72.18
30-34	40.53	26.03	28.85	32.31	38.27	43.33	46.19	58.73
35-39	41.93	39.69	27.60	32.96	38.10	43.88	43.29	48.17
40 and over	50.64	54.73	41.09	41.18	37.25	43.89	56.53	54.26
Secondary or higher	18.48	14.92	18.70	21.27	29.52	36.22	31.26	60.94
Under 20	30.69	24.07	52.69	78.73	41.01	-	-	-
20-24	20.75	13.62	24.33	36.97	54.43	63.10	92.26	58.27
25-29	12.87	8.23	8.58	14.43	36.25	30.70	37.26	80.66
30-34	14.81	9.18	8.57	10.70	17.37	37.69	29.93	65.33
35-39	16.08	10.46	13.57	12.85	7.44	20.69	17.03	48.94
40 and over	23.02	19.77	12.58	19.95	11.24	29.53	10.44	44.78

Source: Instituto Nacional de Estadísticas y Censos.

Table 3. Infant mortality rates (per 1000) by birth order and by mother's age and education, Chile 1972.

Mother's age and level of education	Birth order							
	Total	1	2	3	4	5	6	7 +
Total	74.62	62.07	70.42	73.51	83.11	88.11	93.07	104.35
Under 20	94.57	82.77	117.28	127.86	155.75	102.52	194.39	-
20-24	72.31	53.22	74.20	87.97	104.03	104.49	134.96	175.49
25-29	62.05	44.04	48.46	59.28	75.49	85.55	93.58	119.73
30-34	67.79	52.72	50.05	53.01	64.35	78.49	83.32	96.70
35-39	83.61	68.60	53.36	68.48	80.32	93.66	85.50	98.91
40 and over	96.88	103.61	73.08	77.11	87.62	82.38	93.14	105.62
None	152.88	181.14	180.20	157.20	167.86	147.64	127.90	142.49
Under 20	198.46	203.69	196.03	173.64	249.40	91.57	-	-
20-24	172.24	174.25	188.74	140.12	197.67	137.55	166.05	215.48
25-29	141.57	120.42	183.51	151.27	126.70	125.83	122.25	158.13
30-34	135.01	212.29	126.12	159.76	127.06	140.01	116.71	125.53
35-39	148.97	109.73	61.87	180.11	239.57	195.40	128.13	142.76
40 and over	133.89	126.28	206.54	127.31	134.41	170.87	94.09	131.62
Primary or basic	78.93	73.30	81.14	80.25	81.88	85.37	92.25	96.60
Under 20	96.75	86.74	114.10	122.29	139.92	112.46	-	-
20-24	77.94	61.12	79.28	88.47	94.37	97.52	129.85	160.95
25-29	70.14	58.26	59.24	64.58	73.68	81.58	90.22	109.47
30-34	68.91	55.08	60.16	56.83	62.75	72.92	78.43	87.37
35-39	79.20	80.47	60.21	69.27	72.62	87.08	81.82	85.00
40 and over	94.06	112.76	68.77	83.98	94.31	75.32	96.83	98.12
Secondary or higher	43.10	36.28	41.90	46.68	64.76	70.83	73.39	121.98
Under 20	62.48	49.58	106.83	136.87	202.52	-	-	-
20-24	44.93	34.50	48.75	70.07	97.97	125.23	114.97	230.40
25-29	32.37	24.44	26.08	35.59	62.27	71.00	73.95	152.86
30-34	39.31	31.78	27.46	31.30	50.72	64.19	74.13	120.00
35-39	52.42	41.36	38.82	42.39	53.48	51.26	56.17	121.22
40 and over	58.64	73.31	24.96	44.50	49.98	51.33	72.15	84.86

Source: Instituto Nacional de Estadísticas y Censos.

fertility rate in Costa Rica was known to have dropped sharply in recent years and Mexico, Paraguay, and Peru were considered countries with high fertility rates. Unlike in Chile, death certificates in these countries did not include data on birth order or certain information on the parents of infants who died before their first birthday. The data on infant mortality were obtained directly from interviews with women, noting the number of pregnancies, date of termination, and result of each, and recording the deaths among their live-born children and the age at which they occurred.

Births that occurred in the year prior to the survey were not taken into account because these children might still have died prior to their first birthday, and infant mortality was studied for births that occurred from 1 to 21 years prior to the survey. This time span was selected after analysis showed that it conciliated a relative regularity in infant mortality levels with the need to be able to count on sufficient numbers of births so that subgroups could be analyzed.

The data from the four countries, which were analyzed using the procedure described, covered: July 1955 to June 1975 in Costa Rica and Mexico, February 1958 to January 1978 in Paraguay, and July 1956 to June 1976 in Peru.

Vital statistics from Chile for the 1978 cohort of births were also analyzed, supplementing the studies already conducted for 1972.

For all countries, infant mortality differentials were analyzed with regard to birth order and mother's age and educational level. Also, data from the surveys were used to study differentials in the four countries with regard to previous birth intervals - information that does not appear in Chilean vital statistics - and differentials related to father's occupation - information that was poorly recorded in Chile between 1972 and 1978.

The infant mortality differentials by birth order and mother's age for the 2 years analyzed in Chile and for the four countries for which survey data was available are given in Figs. 2 and 3 and Tables 1-7. All the countries show a rise in infant mortality as birth order increases. Mexico is the only country in which mortality among firstborn children is higher than that of second or third children. With regard to mother's age, the U-curve showing that children of mothers at both ends of the child-bearing span run a greater risk of dying reoccurs in all countries.

Except for some irregularities explained by the scarcity of vital statistics in some categories, Tables 1-7 also show that the U-curve for maternal age applies within the different birth orders. Also, within each maternal age group, infant mortality increases as birth orders. In all birth orders, the highest mortality rates are among children born to women under 20 years of age. This explains why in Mexico, where a high proportion of firstborn are the children of very young women, total mortality for firstborn children is higher than for second children.

Of the three variables related to fertility levels, the length of the intervals between successive births, which could only be studied using data from surveys, is the variable most closely associated with

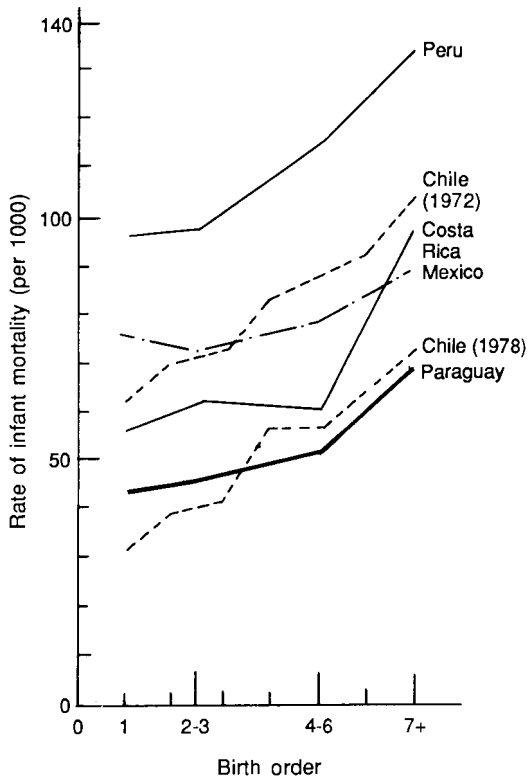

Fig. 2. Infant mortality by birth order in different countries.

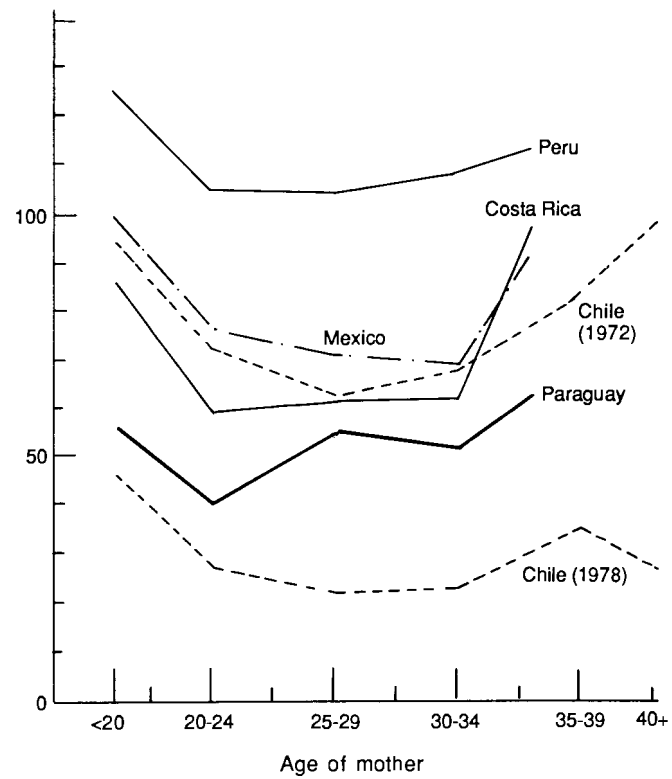

Fig. 3. Infant mortality by mother's age in different countries.

Table 4. Neonatal mortality rates (per 1000) by birth order and by mother's age and education, Chile 1978.

Mother's age and level of education	Birth order							
	Total	1	2	3	4	5	6	7 +
Total	19.92	15.92	19.38	21.83	25.34	27.93	29.98	31.25
Under 20	23.94	19.96	33.42	58.79	67.99	38.79	-	-
20-24	18.74	14.12	19.64	26.05	31.14	40.82	79.07	32.61
25-29	17.64	12.78	16.41	18.29	23.49	24.19	30.27	34.43
30-34	17.87	13.52	12.95	16.41	20.61	24.35	23.70	28.81
35-39	25.07	20.57	17.20	22.30	28.89	27.46	28.30	31.00
40 and over	26.49	12.04	18.81	16.45	20.97	40.17	25.42	32.90
None	40.44	42.95	35.00	33.33	50.59	44.12	32.25	42.66
Under 20	48.47	39.90	59.83	73.05	140.61	-	-	-
20-24	36.75	45.38	20.66	32.14	58.90	37.92	56.25	51.13
25-29	41.35	39.82	36.95	22.72	50.92	50.92	48.30	48.38
30-34	37.21	44.64	36.29	33.92	41.86	31.42	18.34	43.77
35-39	41.43	36.89	41.28	38.79	60.12	8.03	32.85	46.81
40 and over	39.68	102.27	-	27.44	-	152.53	16.79	34.32
Primary or basic	19.77	16.67	20.02	20.20	20.93	27.20	26.76	25.16
Under 20	23.00	19.67	29.64	48.45	59.20	56.25	-	-
20-24	18.80	14.17	19.20	23.29	24.15	39.27	66.17	31.25
25-29	18.02	14.65	18.57	15.88	19.71	22.75	20.99	28.64
30-34	17.48	13.49	13.13	16.78	16.70	22.82	26.90	20.51
35-39	22.62	21.40	14.26	17.94	22.53	34.87	25.34	24.17
40 and over	24.05	9.87	25.50	12.72	23.80	23.50	20.14	30.13
Secondary or higher	18.01	13.83	17.60	23.68	33.25	23.03	51.13	76.38
Under 20	23.71	18.83	44.29	146.24	80.35	-	-	-
20-24	17.66	13.27	20.28	34.15	61.71	64.28	312.48	-
25-29	15.47	10.71	13.85	21.85	31.50	13.97	98.30	73.76
30-34	15.91	12.06	11.86	14.91	25.73	27.94	5.86	102.27
35-39	25.23	18.30	18.70	26.17	35.82	12.16	41.41	61.74
40 and over	25.19	-	10.18	22.39	20.70	38.13	61.63	71.59

Source: Instituto Nacional de Estadísticas y Censos.

Table 5. Post-neonatal mortality rates (per 1000) by birth order and by mother's age and education, Chile 1978.

Mother's age and level of education	Birth order							
	Total	1	2	3	4	5	6	7 +
Total	21.01	16.80	20.05	20.47	30.87	28.70	34.07	41.76
Under 20	31.48	26.92	44.21	57.58	95.68	40.03	-	-
20-24	20.64	13.00	23.25	31.32	43.72	43.25	63.05	117.78
25-29	15.66	9.40	11.37	15.82	24.67	29.53	44.26	50.15
30-34	17.09	8.78	9.42	11.61	22.06	19.84	33.05	46.43
35-39	20.70	14.36	13.20	12.74	16.73	31.17	17.90	35.08
40 and over	29.24	14.49	22.94	15.28	25.58	31.10	32.80	37.63
None	58.41	64.03	55.90	48.38	61.82	56.91	50.90	62.09
Under 20	78.15	72.86	102.92	45.23	72.56	-	-	-
20-24	61.81	69.02	42.64	63.03	91.17	52.17	-	211.08
25-29	50.50	41.10	46.61	35.18	62.11	57.33	56.98	62.41
30-34	53.17	36.86	22.46	40.84	48.60	58.37	44.16	74.53
35-39	40.34	38.07	31.95	50.04	26.59	33.17	42.37	43.63
40 and over	80.57	246.26	145.12	56.63	94.77	118.06	103.96	68.87
Primary or basic	24.79	21.70	24.96	24.05	27.48	26.84	32.22	35.62
Under 20	34.06	29.42	45.47	54.88	99.30	58.05	-	-
20-24	24.72	17.17	25.90	32.16	37.85	37.92	72.85	107.49
25-29	20.58	14.35	16.72	18.75	25.15	27.12	42.24	48.38
30-34	20.08	12.48	12.90	15.16	23.66	16.50	31.12	40.22
35-39	21.45	15.10	13.91	15.43	19.93	34.97	16.20	28.72
40 and over	22.87	10.18	17.54	18.39	12.28	27.28	20.78	29.19
Secondary or higher	10.92	8.72	11.20	11.08	19.20	22.92	29.55	50.16
Under 20	18.54	16.39	25.60	92.88	82.93	-	-	-
20-24	12.54	7.66	17.79	22.92	57.91	99.50	64.50	-
25-29	7.00	4.97	5.46	9.66	14.69	25.24	45.08	38.07
30-34	7.72	3.99	5.67	5.72	14.16	19.23	36.28	40.40
35-39	12.62	11.62	10.22	5.78	8.41	18.83	7.12	92.03
40 and over	11.91	6.25	10.51	-	35.61	-	31.81	10.55

Source: Instituto Nacional de Estadísticas y Censos.

Table 6. Infant mortality rates (per 1000) by birth order and by mother's age and education, Chile 1978.

Mother's age and level of education	Birth order							
	Total	1	2	3	4	5	6	7 +
Total	40.93	32.72	39.43	42.30	56.21	56.63	64.05	73.01
Under 20	55.442	46.88	77.63	116.37	163.67	78.82	-	-
20-24	39.38	27.12	42.89	57.37	74.86	84.07	142.12	150.39
25-29	33.30	22.18	27.78	34.11	48.16	53.72	74.53	84.57
30-34	34.96	22.30	22.37	28.02	42.67	44.19	56.75	75.24
35-39	45.77	34.93	30.40	35.04	45.62	58.63	46.20	66.08
40 and over	55.73	26.53	41.75	31.73	46.55	71.27	58.22	70.53
None	98.85	106.98	90.90	81.71	112.41	101.03	83.15	104.75
Under 20	126.62	112.76	162.75	118.28	213.17	-	-	-
20-24	98.56	114.40	63.30	95.17	150.07	90.09	-.	262.21
25-29	91.81	80.92	83.56	57.90	113.03	108.25	105.28	110.79
30-34	90.38	81.50	58.75	74.76	90.46	89.79	62.50	118.30
35-39	81.77	74.96	73.23	88.83	86.71	41.20	75.22	90.44
40 and over	120.25	348.53	-	84.07	-	270.59	120.75	103.19
Primary or basic	44.56	38.37	44.98	44.25	48.41	54.04	58.98	60.78
Under 20	57.06	49.09	75.11	103.33	158.50	114.30	-	-
20-24	43.52	31.34	45.10	55.45	62.00	77.19	139.02	138.74
25-29	38.60	29.00	35.29	34.63	44.86	49.87	63.23	77.02
30-34	37.56	25.97	26.03	31.94	40.36	39.32	58.02	60.73
35-39	44.07	36.50	28.17	33.37	42.46	69.84	41.54	52.89
40 and over	46.92	20.05	43.04	31.11	36.08	50.78	40.92	59.32
Secondary or higher	28.93	22.55	28.80	34.76	52.45	45.95	80.68	126.54
Under 20	42.25	35.22	69.89	239.12	163.28	-	-	-
20-24	30.20	20.93	38.07	57.07	119.62	163.78	376.98	-
25-29	22.47	15.68	19.31	31.51	46.19	39.21	143.38	111.83
30-34	23.63	16.05	17.53	20.63	39.89	47.17	42.14	142.87
35-39	37.85	29.92	28.92	31.95	44.23	30.99	48.53	153.77
40 and over	37.10	-	20.69	-	56.31	-	93.44	82.14

Source: Instituto Nacional de Estadísticas y Censos.

Table 7. Infant mortality rates (per 1000) by birth order and by mother's age in Costa Rica, Mexico, Paraguay, and Peru.

Birth order	Mother's age					
	Total	20	20-24	25-29	30-34	35 and over
Costa Rica						
Total	67.7	85.6	59.3	61.5	62.0	95.8
1	56.6	69.4	44.5	50.2	(71.4)	-
2-3	62.0	103.2	55.6	58.4	32.0	-
4-6	60.6	(162.8)	75.1	49.0	47.3	98.4
7 and over	97.8	-	(163.9)	103.5	79.7	107.4
Mexico						
Total	78.4	98.5	76.7	69.9	68.0	90.1
1	76.1	86.2	65.7	57.8	(43.0)	(166.7)
2-3	72.7	108.7	68.5	56.4	48.7	(30.9)
4-6	78.5	177.0	95.8	74.1	58.3	77.9
7 and over	89.5	-	(215.4)	83.4	81.2	95.2
Paraguay						
Total	50.9	55.4	40.8	54.1	52.4	61.2
1	43.7	51.0	40.4	34.7	(27.4)	-
2-3	45.1	66.0	36.8	52.3	36.0	(48.8)
4-6	51.4	38.5	53.8	54.0	45.3	50.8
7 and over	69.6	-	-	85.2	68.9	66.6
Peru						
Total	109.4	125.6	105.7	104.1	108.7	112.5
1	95.4	119.9	79.5	(50.3)	(61.9)	(153.9)
2-3	98.5	131.9	101.3	84.1	(76.3)	(54.3)
4-6	115.0	(180.6)	132.9	118.4	97.0	(100.2)
7 and over	134.5	-	(359.4)	(138.2)	137.2	121.2

Source: World Fertility Survey.
Note: (), based on less than 100 births; -, not calculated (less than 30 births or no deaths).

infant mortality. As the interval between successive births increases, the risk of death drops appreciably (Fig. 4; Tables 8 and 9). An analysis by birth order and by mother's age group shows that this behaviour holds true within the categories of these variables.

The mother's education and the father's occupation have a strong influence on the magnitude of infant mortality (Figs. 5 and 6; Table 10). The implications that this has in terms of the differentials for variables related to fertility will be analyzed in greater detail when the biological or socioeconomic nature of these differentials is examined.

Working on the hypothesis that birth structure under conditions of low fertility favours lower infant mortality, a positive association was expected between fertility levels and infant mortality in the different countries studied.

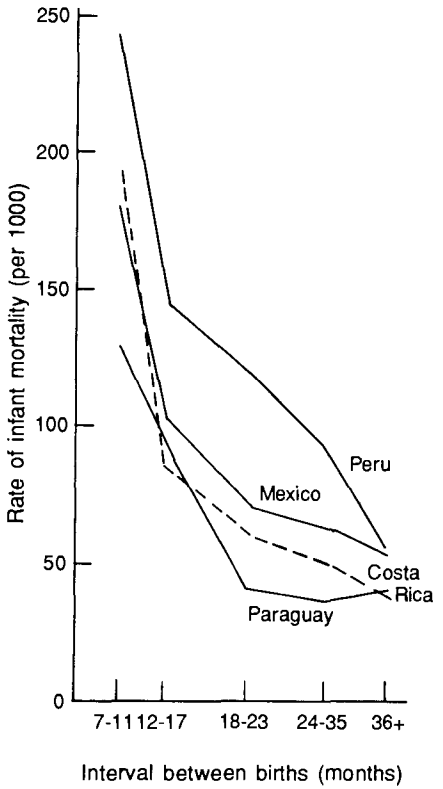

Fig. 4. Infant mortality by length of previous birth interval births in different countries.

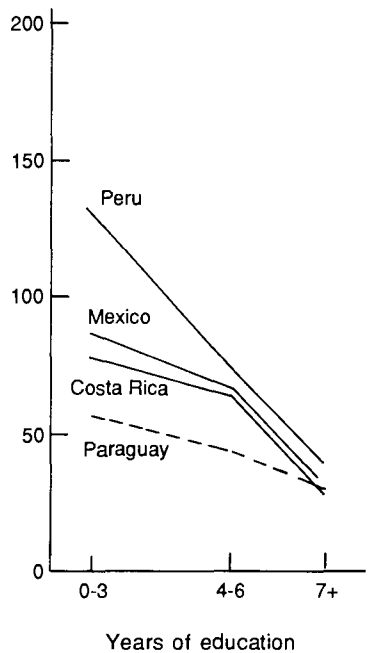

Fig. 5. Infant mortality by years of schooling in different countries.

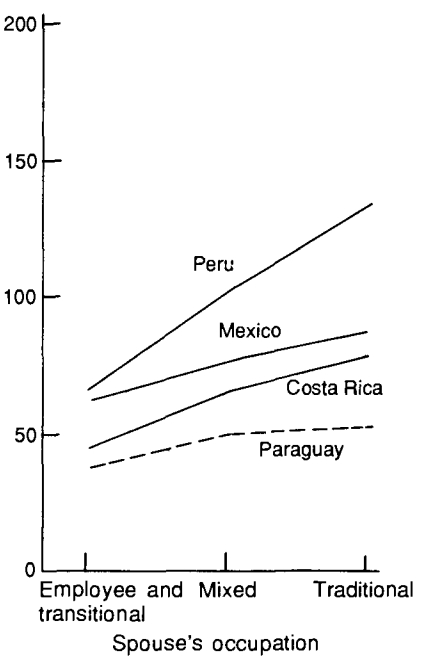

Fig. 6. Infant mortality by spouse's occupation in different countries.

Table 8. Infant mortality rates (per 1000) by birth order and by length of previous birth interval in Costa Rica, Mexico, Paraguay, and Peru.

Birth order	Length of previous birth interval (months)					
	Total	7-11	12-17	18-23	24-35	36 and over
Costa Rica						
Total	70.7	194.0	86.4	60.0	50.3	40.1
2-3	62.0	169.5	71.2	63.4	41.7	32.4
4-6	60.6	171.0	86.4	38.4	43.7	38.3
7 and over	97.8	254.4	112.2	84.0	70.4	59.9
Mexico						
Total	78.8	181.2	103.5	71.8	63.3	55.8
2-3	72.8	175.1	82.5	62.9	65.8	53.2
4-6	78.2	153.4	125.3	74.9	59.1	50.7
7 and over	89.1	227.4	112.3	82.3	66.3	68.4
Paraguay						
Total	52.9	130.4	93.5	41.9	37.4	40.4
2-3	45.1	107.1	66.7	47.2	27.1	39.8
4-6	51.4	121.7	105.1	34.2	38.6	38.9
7 and over	69.6	(168.4)	127.0	44.9	51.3	45.3
Peru						
Total	112.5	244.3	148.6	122.8	96.7	57.5
2-3	98.3	210.5	120.2	116.1	91.3	46.0
4-6	115.0	239.4	155.5	128.9	94.4	65.8
7 and over	134.1	289.8	192.5	125.9	109.8	64.8

Source: World Fertility Survey.
Note: (), based on less than 100 births.

However, levels cannot be reliably determined using data from the surveys which, as has been said, covered a period of 20 years. This point will be discussed in greater detail in chapter 4.

If, based on the results, Costa Rica and Paraguay can be classified as the countries with the lowest fertility and infant mortality rates, then birth structures related to birth order, mother's age, and length of previous birth interval would not rank in high infant mortality risk groups as frequently as in Mexico and Peru.

As expected, with regard to birth order, there was a lower proportion of high-order births in Costa Rica and Paraguay. On the other hand, no association was found between composition by mother's age and fertility levels, or between the latter and the length of previous birth intervals. With regard to this last point, the high proportion of children born at short intervals in Costa Rica, especially among young women, was noteworthy: 46% of children born to women under 25 years of age are born at intervals of less than 18 months in Costa Rica; in Paraguay, this occurs in only 27% of cases. In Costa Rica, the high frequency of short intervals in young women

Table 9. Infant mortality rates (per 1000) by mother's age and by length of previous birth interval in Costa Rica, Mexico, Paraguay, and Peru.

Mother's age	Length of previous birth interval (in months)					
	Total	7-11	12-17	18-24	25-35	36 and over
Costa Rica						
Total	70.7	194.0	86.4	60.0	50.3	40.1
Under 20	109.6	(258.8)	94.4	95.8	74.8	(33.3)
20-24	64.7	184.0	76.0	46.5	38.0	31.3
25-29	62.7	141.2	83.7	55.3	41.7	42.9
30-34	61.6	(202.5)	103.9	56.8	28.8	38.4
35 and over	97.4	(311.1)	100.6	98.3	118.9	46.4
Mexico						
Total	78.8	181.2	103.5	71.8	63.3	55.8
Under 20	115.7	275.0	119.5	105.3	81.3	(21.5)
20-24	80.0	163.7	100.5	55.4	71.0	70.6
25-29	70.4	150.9	101.1	73.0	52.5	45.3
30-34	68.1	179.2	95.7	60.1	57.4	50.4
35 and over	88.8	(180.6)	115.2	114.3	74.5	69.6
Paraguay						
Total	52.9	130.4	93.5	41.9	37.4	40.4
Under 20	64.4	(52.6)	68.2	98.4	31.8	(62.5)
20-24	40.9	(126.4)	68.0	30.3	27.4	29.0
25-29	56.6	(125.0)	106.4	46.2	38.4	45.1
30-34	53.5	(178.1)	111.6	36.7	39.1	32.7
35 and over	62.1	(142.9)	127.8	35.3	53.7	52.2
Peru						
Total	112.6	244.6	148.2	123.4	96.9	57.5
Under 20	134.1	223.1	154.6	146.8	94.0	(25.6)
20-24	114.1	253.1	130.7	116.6	100.5	50.9
25-29	108.9	190.6	145.1	126.7	101.2	50.6
30-34	109.6	314.8	169.8	104.1	87.8	61.0
35 and over	112.1	(275.5)	171.2	157.9	96.5	70.8

Source: World Fertility Survey.
Note: (), based on less than 100 births.

may possibly correspond to births that occurred in years in which the fertility rate was very high. Another explanation may be that, in the low fertility period, women tried to complete their families quickly to the desired number of children. The accuracy of these assumptions could not be explored using the data tabulated.

In the tabulations of the fertility surveys, an important difference was detected between birth structures by mother's educational level. In Costa Rica and Paraguay, about 50% of births involve women with 0-3 years of schooling, whereas in Mexico and Peru, this increases to about 67%. This difference in mothers' educational

Table 10. Infant mortality rates (per 1000) by mother's educational level and spouse's occupation in Costa Rica, Mexico, Paraguay, and Peru.

Mother's years of schooling	Spouse's occupation[a]			
	Total	Employee or transitional	Mixed	Traditional
Costa Rica				
Total	67.2	45.6	66.4	80.6
0-3	79.5	81.5	70.2	83.3
4-6	65.0	42.2	66.2	79.4
7 and over	30.9	21.4	54.8	25.9
Mexico				
Total	78.4	62.3	77.3	89.9
0-3	87.1	76.0	84.7	92.0
4-6	67.4	56.9	71.4	78.7
7 and over	44.6	45.0	37.1	63.0
Paraguay				
Total	50.9	39.4	51.7	54.1
0-3	57.9	59.8	58.8	57.4
4-6	46.9	39.5	53.4	45.4
7 and over	31.7	27.6	27.0	75.3
Peru				
Total	109.5	66.7	104.0	135.7
0-3	132.3	109.2	126.6	139.4
4-6	75.6	61.5	73.2	104.8
7 and over	40.7	29.2	60.3	102.9

Source: World Fertility Survey.

[a]The categories for spouse's occupation are those defined and used in the World Fertility Survey.

levels can be considered a reflection of the general level of education among women in these countries and, given the association normally found between fertility and educational level, it may partly explain the higher fertility levels observed in Mexico and Peru.

Because of the problems mentioned earlier, the relationship between birth structure and fertility levels was only analyzed in greater detail for Chile.

Between 1972 and 1978, the crude birth rate dropped from 28.6 to 21.8 per 1000. Births in order 1, which has the lowest infant mortality rates, rose from 33.5 to 40.4% (Table 11). On the other hand, births in order 4 or higher, which have the highest infant mortality rates, dropped from 28.5 to 18.4%. With regard to birth order, therefore, the structural changes observed in connection with the drop in the fertility rate definitely favour lower infant mortality rates.

The situation is not so clear with regard to structure by mother's age. Although children born to mothers 35 years of age or over dropped from 12.3 to 10.0% from 1972 to 1978, which continues the trend observed earlier, the number of children born to women under 20 years of age rose from 15.9 to 17.3%. In 1978, in Chile, the mortality rate for infants born to women under 20 was somewhat higher than for women of 35 or over. Therefore, the impact on the infant mortality rate of changes in birth structure based on the mother's age practically cancels itself out.

In an update of the study, when 1972 is compared with 1982, it becomes apparent that, in recent years, the number of children born to women under 20 years of age has also been dropping. Thus, changes in structure according to mother's age have a favourable impact on declines in infant mortality.

An examination of the rates by birth order and mother's age contained in Tables 1 to 6 shows that the children with the least risk of dying in the 1st year are those belonging to the first three birth orders whose mothers are from 20 to 34 years of age. The number of these births rose from 52.2 to 60.2% between 1972 and 1978.

Another major change in birth structure in Chile that occurred between the 2 years involves the mother's level of education (Table 11). The birth rate for mothers with secondary or higher education rose from 26.7 to 36.5%; births to mothers with no schooling dropped from 6.9 to 3.8%.

Subsequent studies have shown that, in 1984, births to mothers with secondary or higher education represented 69.6% of the total whereas, for mothers without schooling, they dropped to 2.1%. This change is partly explained by the rise in the educational level of women from 15 to 54 years of age between the 1970 and 1982 censuses.

The same table shows that, between the two censuses, the fertility rate of women with no schooling and with primary education dropped, whereas fertility rose among women with secondary and higher education. Because of differences in grouping the data of the two censuses, these figures cannot be used to make valid comparisons. The 1970 fertility rates were calculated for women up to 54 years of age whereas, in 1982, they were calculated for women up to 49. This means that the earlier rates that deal with a higher denominator are underestimated because an age group that produces few births is included. This invalidates the interpretation that fertility rose among women with more education, but not that it dropped in the other two groups.

Comparing the rates within each year, however, is valid. In 1970, fertility decreased as a woman's educational level rose whereas, in 1982, it increased. This unexpected behaviour in fertility also occurred in 1983. This phenomenon will be interpreted in the section on how reproductive behaviour adapts to economic contingencies.

A study of the impact of changes in birth structure involving birth order and mother's age and level of education on the drop in the birth rate in Chile between 1972 and 1978 showed that these changes accounted for 22% of the drop in total infant mortality, 19% in neonatal mortality, and 22% in postneonatal mortality. The change

with the greatest impact was level of education, followed by the change in composition by birth order. On the other hand, modification of birth structure with respect to maternal age had zero effect. The procedure used to arrive at these figures will be described in another chapter.

It should be kept in mind, however, that a drop in fertility does not always imply structural changes in births that favour lower infant mortality. It is possible that, in countries whose birth rate is just beginning to drop, women from the higher socioeconomic strata are the first to control their fertility. This may shift the birth structure toward an increase in the proportion of mothers whose standards of living are lower. Because of the great impact that socioeconomic factors have on infant mortality, this could lead to an increase in infant mortality by cancelling out the beneficial effects of a drop in the fertility rate in terms of structure by birth order or by length of previous birth interval.

Adaptation of Reproductive Behaviour to Economic Contingencies

The working hypothesis for this analysis was that in a country such as Chile, where the population practices birth control, couples avoid having children when the family economic situation does not ensure favourable conditions for a child. Thus, under unfavourable

Table 11. Birth structure (%) by birth order and by mother's age and educational level, Chile 1972 and 1978.

Variable	1972	1978
Birth order		
1	33.5	40.4
2	23.5	26.8
3	14.5	14.4
4	8.8	7.4
5	5.7	4.0
6	3.9	2.4
7 and over	10.1	4.6
Total	100.0	100.0
Mother's age		
Under 20	15.9	17.3
20-24	31.4	33.5
25-29	25.2	24.6
30-34	15.2	14.6
35-39	8.1	7.2
40 and over	4.2	2.8
Total	100.0	100.0
Mother's education		
None	6.9	3.8
Primary or basic	66.4	59.7
Secondary or higher	26.7	36.5
Total	100.0	100.0

Source: Instituto Nacional de Estadísticas y Censos.

Table 12. Female population from 15 to 54 years of age by number of years of schooling in the 1970 and 1982 censuses and fertility rates by level of education in the same years.[a]

Years of schooling	Female population from 15 to 54 years of age			
	1970		1982	
	No.	%	No.	%
Total	2 284 245	100.0	3 300 530	100.0
0	155 762	6.8	157 341	4.8
1-3	411 997	18.0	325 962	9.9
4-9	1 323 565	58.0	1 637 530	49.6
10 and over	392 921	17.2	1 179 697	35.7

Educational level	Fertility rate (per 1000)	
	1970	1982
Total	104.5	85.0
No schooling	110.8	53.0
Primary	102.6	80.3
Secondary and higher	63.9	92.8

Source: Instituto Nacional de Estadísticas y Censos, 1970 and 1982 censuses, birth statistics. Data prepared by De Lira (1986).

[a]Fertility rates were calculated per 1000 women 15-54 years old in 1970, and per 1000 women 15-49 years old in 1982.

economic circumstances, with increased unemployment or drops in income, children would preferentially be born into families that have not been affected by these contingencies. This would help to explain why the economic crises did not disturb the steady decline in infant mortality in Chile (Taucher 1984).

The best way to verify this hypothesis would be to survey women of child-bearing age. An alternative method would be to study the economic situation of women who have recently had children, abortions, or who make use of family planning services, sampled in adequate numbers. It could be expected that the women in the first group would be in a better economic situation than those in the other two groups. The following analysis using data from 1967 to 1984 anticipates the possibility of conducting an investigation of this kind.

Vital statistics on births in Chile do not permit us to specifically explore whether families in adverse economic situations avoid having children. However, they do make it possible to study whether, unlike with infant mortality, a relationship exists between the evolution of fertility and the fluctuations in economic indicators.

Beginning in 1964, the crude birth rate, which is the roughest indicator of fertility, tended to decline but increased slightly

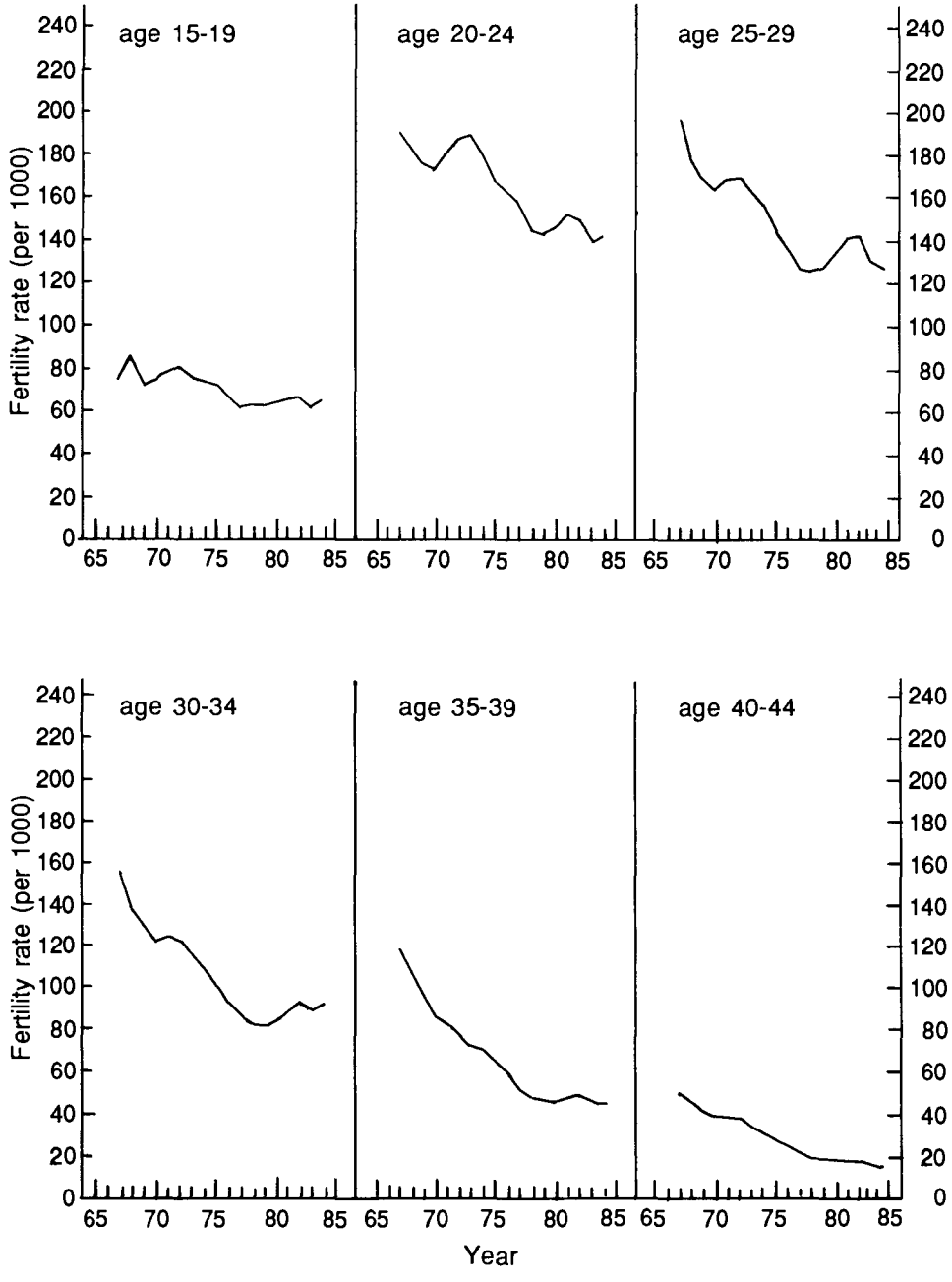

Fig. 7. Specific fertility rates by age, Chile 1967 to 1984.

around 1972 and 1982. The same increases in the specific fertility rates by age are shown in Fig. 7 and Table 13. In both periods, the increase is especially apparent among women 20-24 years of age. However, the second increase is also obvious among women 25-29 years old, among whom the first rise had been less apparent.

Qualitatively, both periods in which fertility increased may coincide with an increase in people's expectations. In the first period, which corresponds to the early years of a leftist government, these would be social expectations. In the second, the expectations would probably be economic. The huge amounts of money borrowed led to an economic upsurge that peaked in 1981. The free import policy placed consumer articles that were never before accessible within reach of modest income sectors. In both periods, therefore, the increase in fertility should occur in the lowest socioeconomic strata.

Another explanation for the second increase may be the change in government family-planning policies that occurred in 1979. With the objective of higher population growth, contraceptives were provided only to persons who asked for them. No data are available to study the impact of this change on the fertility rate. If it were major, it would primarily affect the lower classes who depend on government services for health care and family planning.

To quantitatively relate the evolution of fertility to that of the economic situation, and keeping in mind the sharp drop in large families, the behaviour of total fertility rates was studied by birth

Table 13. Specific fertility rates (per 1000) by age, Chile 1967 to 1984.

	Mother's age						
Year	15-19	20-24	25-29	30-34	35-39	40-44	45-49
1967	74.7	190.3	192.9	153.6	117.0	49.8	7.4
1968	84.4	183.9	179.3	137.9	104.2	46.8	6.9
1969	71.8	174.3	167.1	128.0	94.8	41.8	6.7
1970	73.1	172.9	163.6	121.1	84.9	39.7	6.5
1971	77.4	180.0	166.7	123.3	80.9	38.1	6.1
1972	80.7	187.0	167.1	120.2	76.2	36.6	5.6
1973	77.9	189.0	161.1	114.8	71.1	32.9	5.0
1974	74.2	180.2	156.5	108.8	68.6	31.1	4.9
1975	73.1	167.2	143.0	99.4	64.3	27.8	4.4
1976	66.0	157.5	135.4	90.6	58.9	24.2	4.2
1977	61.9	145.9	125.2	84.3	51.5	20.6	3.4
1978	62.5	143.0	124.6	81.0	47.6	19.1	3.3
1979	61.1	142.0	126.2	81.0	45.7	18.2	2.7
1980	63.4	144.2	133.1	82.3	45.7	17.1	2.5
1981	65.2	151.9	139.8	87.5	46.8	17.6	2.6
1982	65.5	149.3	140.9	91.4	48.1	17.0	2.1
1983	60.8	138.3	129.1	88.4	45.4	15.2	1.7
1984	64.1	141.1	127.6	90.8	45.0	14.4	1.5

Source: Instituto Nacional de Estadísticas y Censos, Anuarios de Demografía (figures not corrected for unrecorded births).

order. Just as for the total fertility rate, the age-specific fertility rates were added for each birth order. These cumulative rates, which are not significant in themselves but which are useful for comparative purposes, showed the same increases and decreases up to the third child as for the specific fertility rates for young women.

The sum of the rates for the first three birth orders (R(1-3)) from 1967 to 1984 is shown in Fig. 8 together with per-capita gross domestic income (GDI) at market prices in 1977 pesos, which was selected as the economic indicator. The sum of the cumulative rates for birth orders 4 and over and infant mortality rates for the same years are shown in Table 14.

It is interesting to note that neither the trend in the infant mortality rate nor that of the sum of the total fertility rates for order 4 and over is related to the behaviour of the economic indicator. On the other hand, the sum of the rates for orders 1 to 3 evolves very similarly to gross domestic income. To determine the association between the two indicators, the coefficients were calculated correlating the fertility index R(1-3) with the economic indicator with different time lags. When R(1-3) is taken for the previous year, the correlation between the two is virtually nil (0.1283); it rises to a maximum 1 year after the economic phenomenon and declines in the following time lags, to drop once again 4 years later (Table 15).

Table 14. Total fertility rate by birth order 1 to 3 (R(1-3)), by order 4 and over (R(4 and over)), per-capita gross national product (GNP) at market prices in thousands of 1977 pesos, and infant mortality rate (IMR), Chile 1967 to 1984.

Year	R(1-3)	R(4 and over)	GNP	IMR
1967	2 163.0	1 765.5	31 332	94.3
1968	2 155.5	1 561.5	31 955	83.5
1969	2 061.5	1 361.0	33 450	78.7
1970	2 076.5	1 232.5	33 417	79.3
1971	2 173.5	1 189.5	35 737	70.5
1972	2 253.0	1 111.4	34 168	71.1
1973	2 240.5	1 018.5	32 465	65.2
1974	2 174.0	947.5	31 932	63.3
1975	2 074.5	821.5	23 791	55.4
1976	1 971.5	712.5	24 788	54.0
1977	1 867.5	596.5	26 553	47.5
1978	1 878.0	527.0	28 151	38.7
1979	1 895.5	489.9	30 595	36.6
1980	1 976.0	465.5	32 223	31.8
1981	2 078.5	478.5	32 250	27.2
1982	2 089.0	482.5	25 695	23.6
1983	1 950.0	439.0	25 431	21.9
1984	2 005.0	417.0	-	19.6

Sources: R(1-3) and R(4 and over) calculated using data from the Instituto Nacional de Estadísticas y Censos (statistics not corrected for unrecorded births); GNP, National Accounts, Banco Central; IMR to 1981, Ministry of Health, 1982-84, Instituto Nacional de Estadísticas.

Table 15. Correlation coefficients for the sum of the cumulative fertility rate for birth orders 1-3 (R(1-3)) with per-capita gross national product for different time lags of R(1-3) with regard to year X in which GNP is measured.

Lag of R(1-3) with respect to GNP (years)	Correlation coefficient r
-1	0.1283
0	0.5501
+1	0.8439
+2	0.8355
+3	0.6045
+4	0.2865

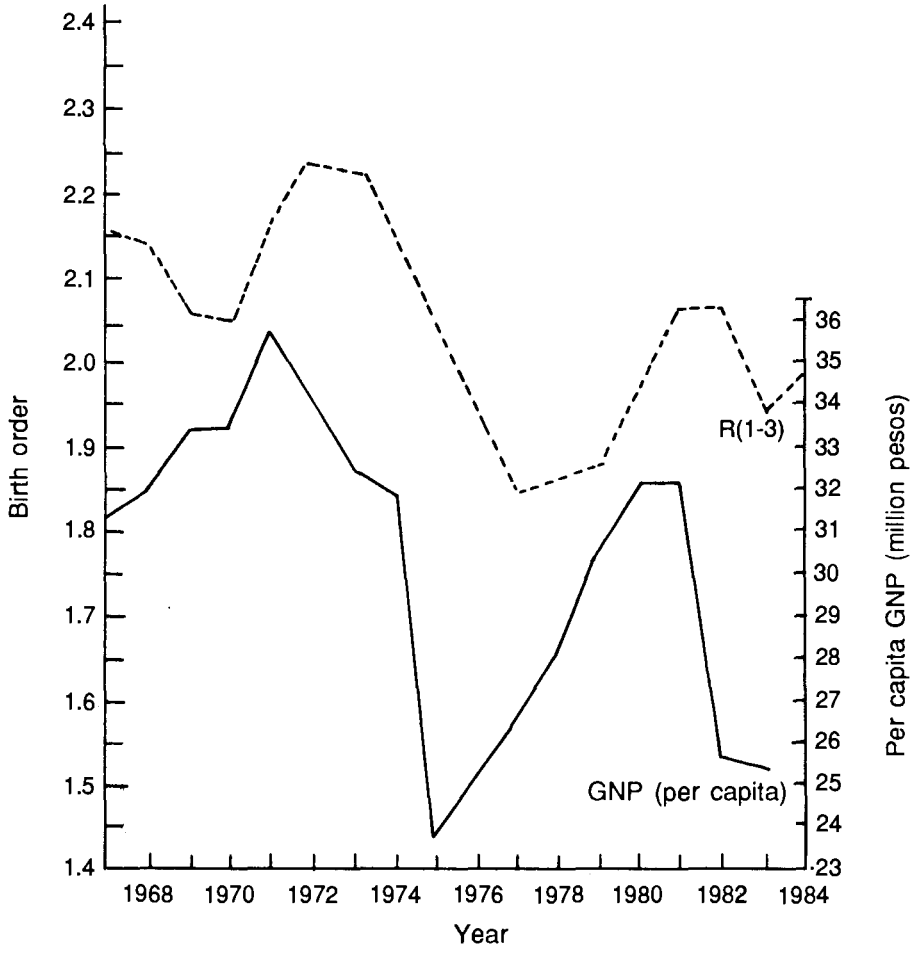

Fig. 8. Sum of cumulative fertility rates for birth orders 1-3 (R(1-3)) and per-capita gross national product at market prices in millions of Chilean pesos, 1967 to 1984.

In spite of this clear relationship between fertility and the economic indicator, the couples most affected by the crisis cannot be affirmed as the ones who stop having children, thereby contributing to the unresponsiveness of infant mortality to economic downswings.

The direct relationship between fertility and a woman's level of education observed in Chile in 1982 provides information that can supplement this analysis. We must work on the assumption that the data are reliable, however, and that a woman's level of education in some way reflects her economic well-being.

Based on these assumptions, the fact that the fertility rate among women with secondary school or advanced education is higher than the rate for groups with less schooling could mean that a significant part of the lower social strata is avoiding having children. This lessens the impact of the government policy of restricting family planning since 1979, because its effect would have translated into an increase in fertility among the lower strata. It also contradicts the interpretation that the economic peak around 1982 favoured sectors with modest incomes. On the other hand, it strengthens the hypothesis that reproductive behaviour adapts to economic contingencies if we take into account the fact that studies by Chilean economists have noted a progressive concentration of wealth and a widening gap in purchasing power between the different social strata.

This could be a subject for research, as was suggested at the outset of this discussion.

Infant Mortality Differentials with Respect to Variables Related to Fertility Levels

Working on the assumption that differentials based on birth order, mother's age, and length of previous birth interval are biological in origin, it was expected that:

- The differentials would be more accute in situations of low infant mortality when the concealing effect of adverse socioeconomic conditions is lessened. This is applicable to situations of both high and low mortality between countries, between two points in time in the same country, and between socioeconomic groups.

- The differentials would be more pronounced in neonatal than in postneonatal mortality because biological factors are assumed to prevail in deaths in the first month of life.

- Endogenous or biological causes of death predominate in the higher mortality groups.

- Infant mortality differentials with respect to variables related to fertility levels should persist when adjusting births in the different categories of these variables for composition by socioeconomic level. This also implies that they should appear within each socioeconomic category.

A methodological problem that arose when attempting to study some of the consequences of this hypothesis was finding a measure that would reflect the magnitude of the differentials. After analyzing

various alternatives, the coefficient of variation, i.e., the ratio between the standard deviation and the simple average of the specific rates in the categories for each variable, was chosen. The main problem is that this measure is based on a small number of rates, corresponding to the small number of categories in each variable, and it does not reflect the shape of the ratio. Nonetheless, because it is a measure of relative variability, it can be accepted as an approximation of the size of the differentials.

With respect to the relationship between infant mortality and birth order, which is approximately linear in form, another method for quantifying the intensity of the differentials was also tried. The linear regression coefficients and the ratio between them and the average of the specific rates for birth order were calculated.

Intensity of Differentials under Conditions of High and Low Infant Mortality

The influence of a conditioning factor that is biological in origin should be more apparent when it is not hidden by socioeconomic determinants. Thus, for example, higher male mortality stands out as levels of general mortality drop. Following the same reasoning, with regard to infant mortality, higher intensity in the differentials can be expected in countries with lower infant mortality. It was also expected that this would be more accentuated in Chile in 1978 than in 1972.

When the coefficients of variation for the rates given in Table 16 are compared, we see that they are higher for the three variables in Paraguay, the country with the lowest infant mortality, than in Peru, the country with the highest. The same situation is observed when comparing the coefficients of variation in Costa Rica,

Table 16. Infant mortality rates and coefficients of variation for specific infant mortality rates by birth order, mother's age, and length of previous birth interval in Costa Rica, Mexico, Paraguay, and Peru.

	Costa Rica	Mexico	Paraguay	Peru
Infant mortality rates[a]	67.7	78.4	50.9	109.4
Coefficients of variation[b]				
Birth order	0.277	0.092	0.228	0.162
Mother's age	0.230	0.164	0.142	0.077
Length of interval	0.728	0.541	0.605	0.524

[a] The time spans for the infant mortality rates and the specific rates are: July 1955 to June 1975 in Costa Rica and Mexico; February 1958 to January 1978 in Paraguay; and July 1956 to June 1976 in Peru.

[b] Coefficient of variation is the ratio between the standard deviation of specific rates and their average ($s/\bar{x}$). It was used here as a measurement of the intensity of differentials. Categories into which the variables were classified: birth order, 1, 2-3, 4-6, 7 and over; mother's age, under 20, 20-24, 25-29, 30-34, 35 and over; length of the interval, 7-11, 12-17, 18-23, 24-35, and 36 months and over.

the other country with low infant mortality, with those in Peru. The association between the size of the differentials and mortality levels becomes more complicated when the four countries are compared because this magnitude does not increase steadily with lower infant mortality.

The relation between the regression coefficient and average infant mortality rates by birth order is closer for Costa Rica and Paraguay, with low mortality, than for Mexico and Peru, with high mortality (Table 17).

In Chile, where infant mortality dropped from 74.6 in 1972 to 40.9 in 1978, the coefficients of variation for rates by birth order rose from 0.177 to 0.277 between the 2 years, and the coefficients of

Table 17. Linear regression coefficients (b) between specific infant mortality rates and birth order, and the ratio between these coefficients and average infant mortality rates by birth order ($\bar{y}$).

Rate, country, group	b	b/$\bar{y}$
Infant mortality		
Costa Rica	4.98	0.0719
Mexico	1.90	0.0240
Paraguay	3.33	0.0635
Peru	5.10	0.0460
Chile 1972	5.33	0.0649
Chile 1978	5.21	0.1001
Neonatal mortality		
Chile 1972	1.56	0.0463
Chile 1978	2.00	0.0815
Postneonatal mortality		
Chile 1972	3.76	0.0779
Chile 1978	3.21	0.1168
Neonatal mortality, Chile 1972		
No schooling	-3.14	-0.0556
Primary or basic	0.85	0.0261
Secondary or higher	5.04	0.1452
Neonatal mortality, Chile 1978		
No schooling	0.22	0.0054
Primary or basic	1.18	0.0528
Secondary or higher	7.80	0.2284
Postneonatal mortality, Chile 1972		
No schooling	-2.86	0.0282
Primary or basic	1.95	0.0377
Secondary or higher	5.51	0.1812
Postneonatal mortality, Chile 1978		
No schooling	0.06	0.0010
Primary or basic	1.73	0.0628
Secondary or higher	5.28	0.2421

variation for the rates based on mother's age rose over the same period from 0.181 to 0.224. Table 17 also shows an increase in the ratio between the regression coefficient and the average rates for birth order between 1972 and 1978, both for infant mortality and for its components, neonatal and postneonatal mortality.

If the magnitude of infant mortality differentials by birth order, mother's age, and length of the interval between births is analyzed, measured in terms of coefficients of variation in children born to mothers with different levels of education, a trend becomes obvious toward a rise in magnitude as the educational level rises (Table 18). The higher intensity of the differentials in the higher education category is especially visible in Chile, where it can also be seen (Table 17) that the ratio between the slope of the rates per birth order and the average of these rates increases considerably as the mother's level of education rises.

Despite all the drawbacks of the coefficient of variation or the regression coefficient in relation to the average rate as a measurement of the intensity of differentials, and with the problems involved in cataloguing the countries by infant mortality level, the findings confirm that the differentials are more intense under conditions of low infant mortality. This agrees with the hypothesis that these differentials are biological in nature.

Table 18. Coefficients of variation for specific mortality rates by birth order, mother's age, and length of previous birth interval within categories of the mother's educational level in Costa Rica, Mexico, Paraguay, Peru, and Chile (1972 and 1978).

Mother's level of education[a]	Costa Rica	Mexico	Paraguay	Peru	Chile	
					1972	1978
Birth order						
Low	0.1597	0.1074	0.1769	0.0593	0.1262	0.1242
Medium	0.3247	0.1538	0.2312	0.1256	0.0929	0.1653
High	0.1817	0.2875	0.2476	0.2492	0.4453	0.6528
Mother's age						
Low	0.1361	0.1598	0.1816	0.0841	0.1644	0.1760
Medium	0.3448	0.0973	0.1932	0.1735	0.1453	0.1577
High	0.3797	0.5339	0.4802	0.1306	0.2395	0.2515
Length of previous birth interval						
Low	0.6136	0.5083	0.5415	0.5049	-	-
Medium	0.8129	0.7282	0.6229	0.5186	-	-
High	0.2404	0.1553	0.6527	0.4113	-	-

[a] In Costa Rica, Mexico, Paraguay, and Peru, low is under 4 years of schooling; medium, 4-6 years; high, 7 or more years. In Chile, low represents no schooling; medium, primary or basic; high, secondary or advanced education.

Intensity of Differentials in Neonatal and Postneonatal Mortality

It is commonly accepted that causes of death in the 1st month of life are usually biological or endogenous in nature, unlike mortality between 1 and 11 months, when exogenous causes would predominate that are linked to unfavourable factors in the environment, nutrition, etc. Therefore, mortality differentials by birth order and mother's age will be more pronounced in neonatal mortality. Data for Chile in 1972 and 1978 were analyzed because it was the only country for which vital statistics were available and in which the number of births and deaths was sufficient to subdivide these two components of infant mortality.

Neonatal and postneonatal mortality rates by birth order and mother's age are shown in Tables 1, 2, 4, and 5. The coefficients of variation of the rates were also calculated as a measurement of the magnitude of the differentials. Contrary to what was expected under the biological assumption, the differentials by birth order are more intense in postneonatal mortality than in neonatal mortality in the 2 years studied. The differentials by mother's age behave ambiguously. In 1972, they are more pronounced for neonatal mortality, whereas the contrary is true in 1978.

Analyzing the coefficients of variation, the highest magnitude continues to occur in the differentials by birth order for post-neonatal mortality; this is contrary to what was expected. However, the differentials are consistently higher for children of highly educated mothers than for those whose mothers had little schooling, and they are more pronounced in 1978, when mortality had dropped, than in 1972. These two observations support the biological nature of the differentials.

Coefficients of variation in mortality rates by mother's age, with certain exceptions in 1972 but for all groups in 1978, are higher for postneonatal mortality than for neonatal mortality. In both years, the magnitude is higher for children of mothers with high educational levels than for those with poorly educated mothers. The coefficients of variation increase in 1978 over 1972 in relation to the decline in mortality. The only exceptions to this rule are neonatal mortality rates by mother's age in firstborn children, for which the coefficients drop in 1978, a fact that is still apparent when no subclassification is made by birth order.

Although the biological origin assumption did not lead us to expect that differentials by birth order and mother's age would be more intense in postneonatal mortality than in neonatal mortality, the fact that they became more marked when mortality dropped between 1972 and 1978 and are more pronounced in the offspring of mothers with more education does agree with the assumption. The first discrepancy could be explained either because of the predominantly nonendogenous nature of the causes of death in the first month of life or because of a differential vulnerability to external factors that cause death between 1 and 11 months of age.

Predominance of Endogenous Causes in Highest Mortality Groups

An analysis of mortality by cause of death for different categories of birth order and mother's age should be the best means of

revealing the nature of the mortality differentials for these variables. We would expect that an excess number of deaths due to endogenous or biological causes is the explanation for the greater risk of death in some groups.

In undertaking a study of this kind, it is necessary to define causes that are considered endogenous, i.e., related to biological deficiencies according to the classification made by Burgeois-Pichat (1951), and those which should be classified as exogenous, i.e., conditioned by external factors that are socioeconomic in nature. Because of the complexity of the process that leads to death, identifying a cause as purely endogenous or purely exogenous is very difficult. For example, congenital defects that appear to be typical examples of endogenous causes may originate in genetic alterations or in disturbances in the development of the embryo caused by drugs, radioactivity, or infections, which are exogenous factors. In turn, diarrhea, a disease mainly attributable to poor sanitary conditions, and therefore exogenous, will generally lead to death only in children with the least biological potential, e.g., with low birth weights or suffering from malnutrition. The same can be said of respiratory and infectious diseases. With all of them, accessibility to timely and efficient medical care is also a key factor.

Using vital statistics from Chile for 1972 and 1978, differentials were analyzed by birth order and mother's age for different causes of death, for both neonatal and postneonatal mortality. In each of the groups of causes, mortality follows behavioural patterns similar to total mortality, which in turn means that the composition by cause of death of groups based on birth order or mother's age is similar (Taucher 1985). Instead of too many deaths due to endogenous causes in the highest mortality groups, therefore, vulnerability to death from any cause seems to increase with birth order and is higher when the mother belongs to a group at either extreme of the age range.

Independence of Differentials Based on Variables Related to Fertility and Socioeconomic Factors

If the differentials by birth order, mother's age, and length of previous birth interval are mainly biological in origin, they should persist within the different socioeconomic strata. On the other hand, if they are mainly determined by the predominant presence of low socioeconomic strata in the highest mortality groups, within each stratum, therefore, no differentials should be observed with respect to the variables under discussion.

The corresponding studies (Taucher 1982b, 1985) showed that the mortality differentials for birth order, mother's age, and length of previous birth interval continue to hold within the different educational groups for women in the four countries from which data from fertility surveys were analyzed. The figures from Chile given in Tables 1-6 also lead to the same conclusion.

Obviously, the mother's level of education is only one indicator of socioeconomic level, and by using it as a classifier, all the external factors that could influence the magnitude of the differentials are not necessarily controlled. However, the mother's

level of education has been shown to be so closely linked to the level of infant mortality, fertility rates, and behavioural variables that the results found for its subdivisions are important.

Doubt is cast on the hypothesis that the high infant mortality observed when birth orders are high, mothers are at extremes of the child bearing span, and previous birth intervals are short is biological in nature, because more women from lower socioeconomic classes are in these groups than in the groups for which mortality is lower.

To see whether this could be the real explanation for the differentials observed, the percentage of children born to mothers with little schooling in each category of birth order, mother's age, and previous birth interval was calculated. The percentage of mothers with little schooling increases with birth order and behaves as a U with regard to the mother's age (Fig. 9, Table 19), mirroring the relation between infant mortality and the groupings of these variables shown in Figs. 2 and 3. The previous birth interval, on the other hand, is not associated with the mother's level of education.

Table 19. Percentage of mothers with little education[a] in categories of birth order, mother's age, and length of previous birth interval in different countries.

	Costa Rica	Mexico	Paraguay	Peru	Chile 1972	Chile 1978
Birth order						
1	30.3	53.9	36.6	52.8	64.0	56.1
2-3	39.6	61.2	44.0	61.0	69.8	61.5
4-6	55.9	71.7	60.6	74.0	85.3	81.2
7 and over	67.7	79.5	73.8	83.9	95.5	95.1
Total	47.8	66.7	52.3	67.6	73.3	63.6
Mother's age						
Under 20	38.6	66.1	51.6	63.4	79.4	75.0
20-24	41.7	61.6	44.0	61.6	70.2	59.5
25-29	51.0	65.4	50.6	66.6	67.4	57.0
30-34	54.7	72.1	58.5	74.3	74.7	62.5
35 and over	62.5	77.9	68.4	80.1	83.8	74.9
Total	47.8	66.7	52.3	67.6	73.3	63.6
Length of previous birth interval						
7-11	55.5	72.8	41.9	78.0	-	-
12-17	53.5	62.3	55.7	65.5	-	-
18-23	53.0	69.3	58.2	68.6	-	-
24-35	56.4	73.2	57.9	74.5	-	-
36 and over	44.3	71.4	53.4	71.0	-	-
Total	52.5	69.6	56.7	71.0	-	-

[a]Low educational level: Chile, no schooling or primary school; other countries, 0-3 years of schooling.

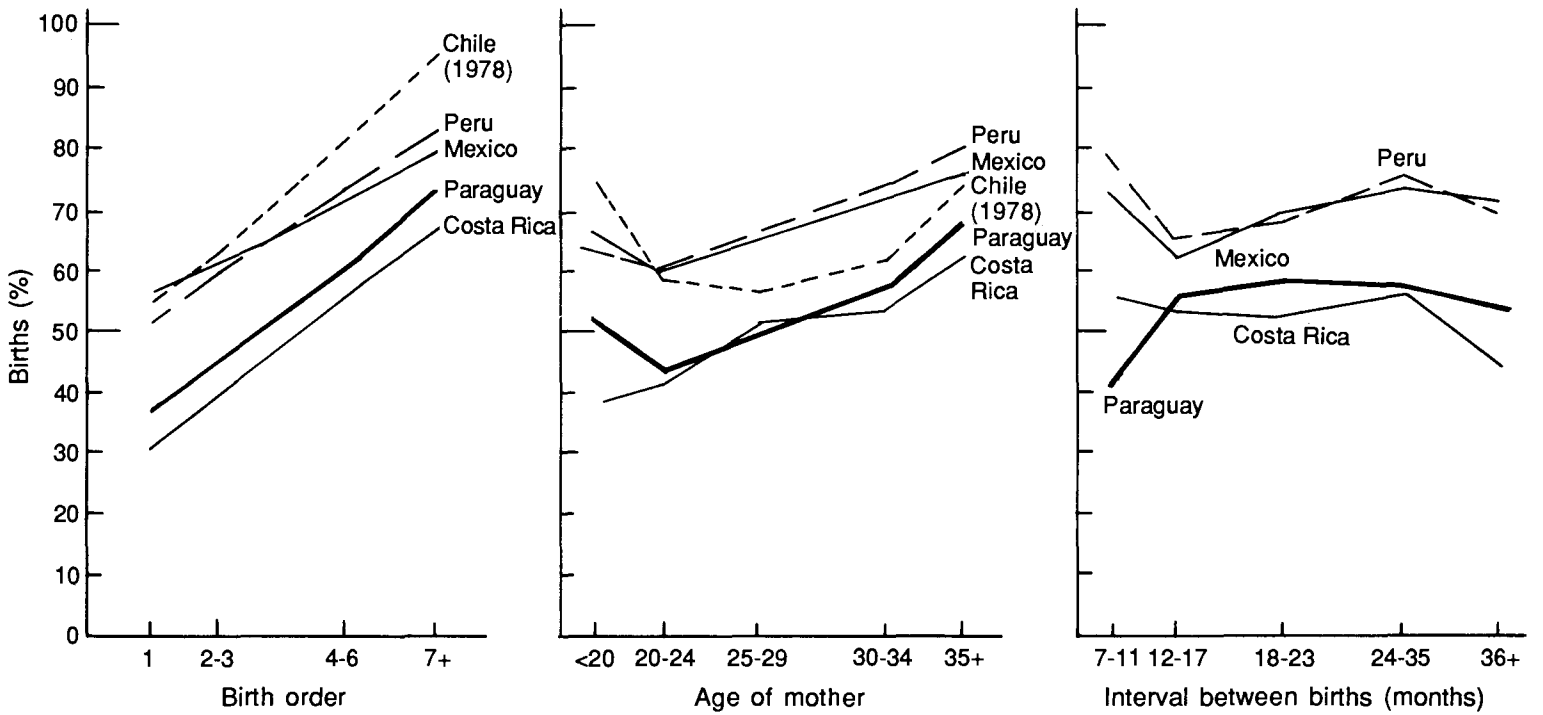

Fig. 9. Percentage of children born to mothers with little education (Chile, no schooling or primary education; other countries, 0-3 years of school) by birth order, mother's age, and previous birth interval.

When rates by birth order and by mother's age in each country are standardized according to mother's level of education for total births (Table 20), the differentials remain virtually unchanged when the influence of mother's level of education is eliminated (Fig. 10). The specific rates for previous birth intervals were not standardized because of the slight differences apparent when broken down by mother's level of education.

Similar results were found when standardizing the rates for neonatal, postneonatal, and infant mortality by birth order and mother's age according to mother's level of education in Chile in 1972 and 1978.

Therefore, it was concluded that factors that support the biological nature hypothesis are: the persistence of infant mortality differentials by birth order, mother's age, and length of previous birth interval within the different groupings by mother's level of education; the sharpening of the differentials as the level of education rises; and the little influence that the mother's level of education has on the differentials.

Conclusions

Summarizing the foregoing findings, the fact that mortality differentials by birth order, mother's age, and previous birth interval continue to be maintained within the different groupings for mother's level of education supports the biological nature of their

Table 20. Infant mortality rates by birth order and mother's age observed and standardized by birth composition with respect to mother's level of education[a] in Costa Rica, Mexico, Paraguay, and Peru.

	Costa Rica		Mexico		Paraguay		Peru	
	Obs.	Stand.	Obs.	Stand.	Obs.	Stand.	Obs.	Stand.
Birth order								
1	56.65	62.32	76.16	80.02	43.69	44.71	95.64	107.04
2-3	62.05	64.21	72.75	74.90	45.08	46.86	98.40	102.95
4-6	60.62	69.27	78.48	77.83	51.35	51.02	115.36	111.74
7 and over	97.77	97.09	89.49	87.70	69.61	68.17	134.29	124.47
Mother's age								
Under 20	85.56	87.03	98.45	98.63	55.36	55.49	125.63	128.53
20-24	59.29	60.89	76.78	78.63	40.78	40.68	105.87	110.50
25-29	61.58	60.45	69.88	70.12	54.05	54.33	104.10	104.79
30-34	62.09	60.34	68.03	66.86	52.35	50.58	108.39	104.21
35 and over	95.89	95.45	90.15	88.06	61.19	59.58	112.64	105.12

[a]The percentages by educational level used for standardization were: Costa Rica, 47.83 and 52.17 (for 0-3 and 4 and more years of education); Mexico, 66.67 and 33.33; Paraguay, 52.25 and 47.75; Peru 67.55 and 32.45.

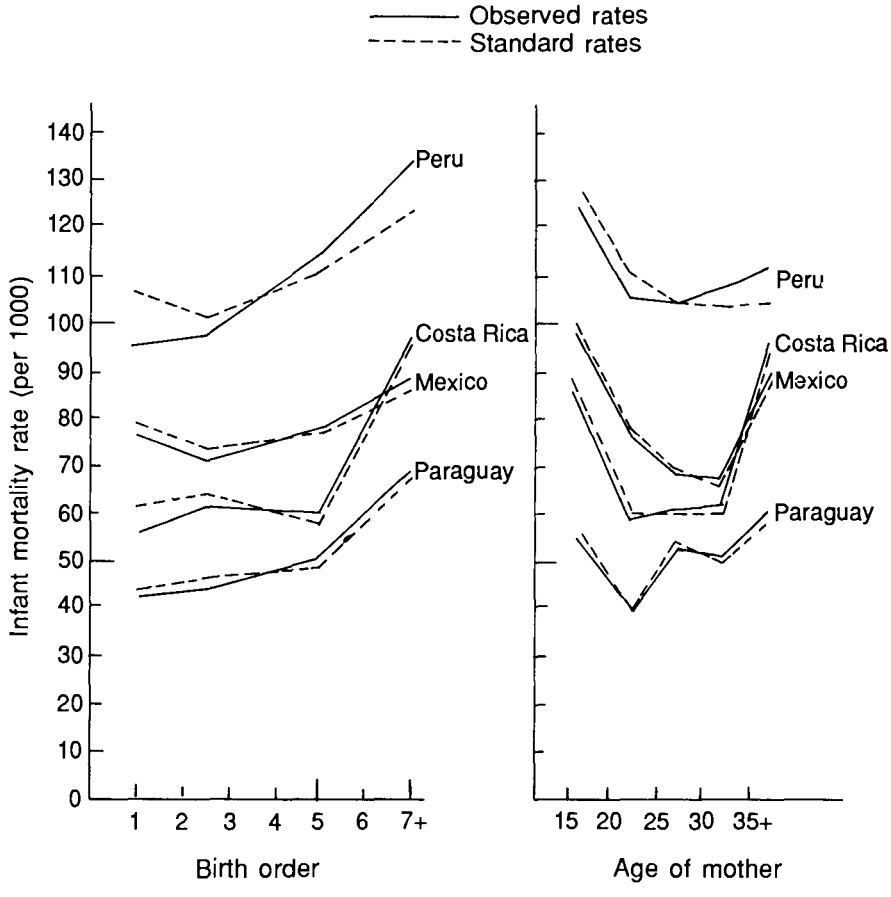

Fig. 10. Infant mortality by birth order and mother's age in Costa Rica, Mexico, Paraguay, and Peru. Observed and standardized rates by mother's level of education.

origin. The same interpretation can be given to the fact that the specific rates for these variables, standardized by composition according to mother's level of education, are similar to the observed rates.

The facts that the differentials are not more intense in the groups with low infant mortality and that intensity is higher in postneonatal mortality than in neonatal mortality contradict and oppose the hypothesis suggested.

CHAPTER 2: PROBLEMS WITH DATA

Data Sources

Selection of a data source depends not only on its completeness and quality, but also on the specific aspect that is to be studied. The discussion here will be approached from the latter viewpoint.

Analysis of Levels and Trends

The most suitable source for studying infant mortality and fertility trends is vital statistics records, because they pinpoint levels at precise moments in time. The problem is that many developing countries record vital statistics incompletely or restrict them to selected segments of the population.

If underrecording could be estimated, corrections could be made to obtain values closer to the true magnitude of the rates. Even if corrections are not made, however, if no major changes have occurred in the extent of underrecording, the behaviour of fertility and mortality trends can still be studied but on an inexact level.

If the birth or death records, or both, gradually improve, we must find out which has improved the most and how much so that the effect on the indexes can be estimated to better interpret the evolution of rates.

Undoubtedly, information from surveys, even when collected directly from women who have had children, is a less efficient source for estimating levels of fertility and infant mortality over time.

In the study using the surveys from Costa Rica, Mexico, Paraguay, and Peru, because these were retrospective surveys of women from 15 to 49 years of age, the births declared mainly corresponded to young mothers and to different times during the 20 years studied. On the other hand, births to older women were scarce and occurred more recently.

Thus, to obtain a measurement of the total fertility for different periods prior to the survey, specific fertility rates for older women were extrapolated from data declared by younger women for the period in question, with the consequent possibility of errors in the estimate.

This problem also affects total infant mortality rates that, for those based on data removed in time from the survey, correspond to

births with a higher proportion of young mothers, to lower birth orders, and to times in which infant mortality was higher, factors that act differently on the level of the rate.

Data for three 5-year periods for which total fertility rates were estimated using data from the surveys are given in Table 21. Infant mortality rates were calculated for the same 5-year periods. The Chilean data are averages of rates calculated using vital statistics published by the Instituto de Estadísticas y Censos.

It is not easy to classify the countries according to their fertility levels. For example, Chile and Costa Rica have rates that are much lower than the other countries for the most recent 5-year period, but from 1961 to 1965, Costa Rica had a total fertility rate higher than Paraguay or Peru.

A study of the link between fertility levels and infant mortality shows that it is not strong enough to wipe out the differences between countries; for similar total fertility rates very different infant mortality rates are found. On the other hand, within countries and with the exception of Paraguay, a drop in fertility is accompanied by a drop in infant mortality.

Analysis of Differentials

For a study of infant mortality differentials, the fact that the survey covers a lengthy retrospective period is a minor inconvenience, because both infant deaths and the births from which they derive are affected by the same bias. However, the higher proportion of births in lower birth orders and at younger maternal ages in periods removed in time from the survey, and the opposite, births in high birth orders and to older mothers closer to the present can distort the magnitude of the differentials. If the infant mortality rate has dropped in the period covered, this favours recent events.

The advantage of surveys for the study of differentials is that the data for the numerator and denominator of the rates and for classifying into different categories are provided by the same informant.

Aside from surveying histories of pregnancies, the indirect estimating techniques developed by Brass and his disciples are useful in obtaining data to calculate differentials. They can even serve to analyze differentials using census data, avoiding the need to conduct special surveys.

The main problem in using vital statistics is that, although the information for which we wish to obtain infant mortality differentials frequently appears on birth certificates, it is rarely included in death certificates for infants of under 1 year.

When the investigation was conducted in the five Latin American countries, only Chile recorded information on birth order and the characteristics of parents in death certificates for children of under 1 year.

The other problem is that if complete information is not recorded for both events, the rates will contain errors whose meaning will be

Table 21. Infant mortality rates (IMR) and total fertility rates (TFR) in 5-year periods in Costa Rica, Mexico, Paraguay, Peru, and Chile.

	1961-1965	1966-1970	1971-1975
Costa Rica			
IMR	78.6	72.1	51.8
TFR	7.2	5.5	3.8
Mexico			
IMR	86.9	76.4	67.0
TFR	7.4	6.9	6.2
Paraguay			
IMR	45.7	51.4	52.4
TFR	6.6	6.1	5.3
Peru			
IMR	116.6	105.0	100.9
TFR	6.8	6.4	5.5
Chile			
IMR	103.1	86.7	65.1
TFR	5.2	4.7	3.2

Sources: IMR in Costa Rica, Mexico, Paraguay, and Peru, special tabulations; TFR in Costa Rica, Mexico, Paraguay, and Peru, Bocaz (1981); Chile, Instituto Nacional de Estadísticas y Censos.

difficult to determine. For example, in Chile, infant mortality rates by father's occupation could not be analyzed in 1978 because this information was missing from 11% of birth records and 34% of death certificates. This meant that the mother's educational level had to be used as the socioeconomic indicator, because it was recorded more often. Birth order and mother's age, on the other hand, are thoroughly recorded.

One precaution taken to arrive at purer differentials was to analyze deaths in birth cohorts for 1972 and 1978. The deaths of children under 1 year of age in 1972 and 1973, corresponding to births in 1972, were used. The same was done with births in 1978, by choosing deaths in the year 1978 and 1979.

Some countries provide information in the birth certificate but not in the death certificate for an infant under 1 year of age. If the records are sufficiently complete in these cases, the certificates can be compared. This involves a great deal of work if not done by computer, but occasionally the wealth of information obtained justifies it. Vital statistics are also the only adequate source for studying the causes of death.

Number of Vital Events

The most serious problem in most surveys is the small number of vital events they contribute to an analysis. Therefore, when specific

rates for various subclassifications of variables are constructed, the rates become very unstable or such broad categories must be used that the objective of an analysis of differentials is lost.

The numbers of births and infant deaths that could be analyzed in the four countries are compared in Table 22 using data from the fertility survey for a 20-year period and in Chile using vital statistics.

Vital Statistics Versus Surveys

Summarizing the above, if specific infant mortality rates are to be calculated by different variables, the data in the numerator and the denominator must be as similar in quality as possible. This is generally true for data from surveys provided by the same informants.

When the data for classification are recorded in birth and death certificates for children under 1 year of age, and the records are complete and reliable, vital statistics can compete favourably with data from surveys. First, they provide more stable rates for a larger number of vital events available for analysis. Second, they have the great advantage of referring to a precise time and, therefore, permit changes over time to be studied.

Brass's method, relating to the second-last child (Brass and Macrae 1984), combines the advantages of surveys, by providing data from the same informants, and of vital statistics, because they can be assigned to a precise time. Mothers are asked, at the time a new child is born, whether the previous child is still living. The question can be refined by asking whether, in the event the child died, it had reached its first birthday.

This method could be very useful for countries in which birth records, but not death records, are complete. If the question is included in the birth certificate and is asked with all live births that do not involve a firstborn, a continuous estimate would be obtained, with a lag of a few years, on levels of infant mortality. In addition, infant mortality differentials can be calculated and

Table 22. Number of births and deaths of infants under 1 year of age in the countries studied.

Country	Year[a]	Births	Deaths
Costa Rica	1955-1975	11093	751
Mexico	1955-1975	22720	1782
Paraguay	1958-1978	9319	474
Peru	1956-1976	20706	2266
Chile	1972	256097	19081
	1978	218581	8948

[a]For the countries in which data from fertility surveys were analyzed, the data on births correspond to those that took place between 1 and 21 years prior to the survey. The deaths are those corresponding to these births.

relationships between infant mortality and fertility can be determined for different administrative divisions in a country.

Analysis of Data Quality

The possibility of testing the quality of information on the deaths of infants under 1 year obtained from the fertility surveys was very limited. Even in Costa Rica, which keeps good vital statistics, comparing infant mortality rates obtained from the survey with those obtained from vital statistics was impossible. For periods removed in time from the date of the survey, the births declared during the interviews correspond to the children of women who were younger on average than women for whom birth statistics were registered at the same time, and therefore, to lower birth orders than those contained in the vital statistics.

Data from Chilean vital statistics were used without correction for possible omissions from registration. Officially, births are estimated to be underregistered by around 5% but death records are supposedly complete. According to a study by Legarreta et al. (1973), this is not true for deaths of infants under 1 year. Means are not available, however, to determine the precise number of omissions or to learn whether this could be a differential depending on the characteristics of the mother for both births and deaths. Assuming that omissions exist, if they have not changed over time and they are not differential, no major problems would be posed for comparative analysis.

Other Problems with the Data

When it was noted in Chile that the proportion of children born to mothers with high levels of education had increased, for a long time it was asked whether this was because the educational level of the female population had increased or fertility in groups of women with less schooling had dropped. Data from the 1982 census were awaited with curiosity to see which of the two factors weighed more in changes in birth structure.

Unfortunately, it was impossible to determine specific fertility rates by women's level of education that could be compared between the two census years. Tabulations for the 1970 census grouped the female population by type of education into none, primary, secondary, and advanced. On the other hand, in 1982, the data were published by the number of years of schooling. The group from 7-9 years contains part of primary or basic education and part of secondary or high school education. Births up to 1982 were published by type of education received by the mother. After 1983, births are published by number of years that the mother studied, with the same grouping as for the population census. Although this makes it possible to calculate specific fertility rates by level of schooling, it does not allow for a comparison with the rates for 1970 when other classification criteria were used.

Changes in tabulation criteria are not restricted to this particular case alone. For example, between the eighth and ninth revisions of the International Classification of Diseases, major

changes were made in the groupings of causes of death that have made it almost impossible to analyze time series by cause of death, especially for neonatal mortality.

National and international organizations should keep in mind the impact that changes in certificates, data grouping criteria, and coding criteria have on the continuity of statistical series.

CHAPTER 3: STANDARDIZATION METHODS TO MEASURE THE EFFECT OF DECLINING FERTILITY ON INFANT MORTALITY LEVELS

The correlation between different fertility indicators and the infant mortality rate over time, for different countries or for regions in the same country, does not allow causality to be deduced. Nor does it allow us to say which is the explanatory factor and which is the consequence. We can only conclude that the two are associated, probably because the levels obey common determinants, which does not exclude the possibility that they may also have reciprocal relations independent of these common conditioning factors.

The problem is particularly serious when making correlations for data in time series over a given period. Any variable with a regular temporal trend to rise or fall will be strongly correlated with another that has a similar trend.

In correlations made to measure fertility and infant mortality rates by country or geographical area, the added problem exists that records of births or deaths may differ in quality, and this can hide the true relation between the variables.

For these reasons, measurements of the impact of a decrease in fertility on infant mortality levels were approached in the works referred to here in terms of the influence of the changes in birth structure that can be attributed to decreasing fertility. To make such measurements, the standardization methods described below were used.

Application of an Indirect Standardization Method to Chilean Data from 1965 to 1972

Between 1965, when the decline in fertility in Chile began, and 1972, the last year for which detailed data on births by order and mother's age were available at the time the study was conducted (Taucher 1979a), a strong shift occurred in birth structure toward lower birth orders and younger maternal ages.

To quantify the influence of these changes in birth structure on the infant mortality level, the method used by Morris et al. (1975) was employed. Using specific rates for birth order, for mother's age, and for both variables at the same time, obtained from the cohort of births in 1972, we calculated deaths and the expected rates according to the particular structure of births registered each year and published by the Instituto Nacional de Estadísticas for each year from 1965 to 1971. The resulting rates can be seen in Table 23.

Table 23. Observed and expected infant mortality rates due to changes in birth structure involving birth order, mother's age, and both simultaneously, Chile.

Year	Observed rates[a]	Expected rates[b] due to the effects of		
		Birth order	Mother's Age	Order and age
1965	107.43	72.17	67.78	72.56
1966	108.42	71.66	67.85	72.02
1967	99.99	71.10	67.95	71.56
1968	91.72	70.50	67.94	70.76
1969	86.88	69.65	68.01	69.70
1970	87.40	68.89	67.89	68.88
1971	78.36	68.58	67.93	68.53
1972	67.97[c]	67.97	67.97	67.97

Note: Lines adjusted by minimum squares: $\hat{y}$ observed = 116.1532 - 5.5849x; $\hat{y}$ order = 72.8657 - 0.6224x; $\hat{y}$ age = 67.8282 + 0.0193x; $\hat{y}$ order and age = 73.3911 - 0.6986x.

[a]Calculated using births uncorrected for omissions published by the Instituto Nacional de Estadísticas.

[b]Calculated by applying the specific rates for the 1972 birth cohort to births recorded each year in the corresponding categories.

[c]Rate for the 1972 birth cohort.

Next, straight lines were adjusted following the least squares method to the rates observed from 1965 to 1972 and to the rates calculated for each year for the different birth structures (Fig. 11).

If 1972 is taken as the reference year, the line adjusted to the expected rates would have had a 0 slope if the birth structure had remained unchanged over the entire period under study. The negative slopes that, on the contrary, are observed in the adjusted lines both for the expected rates for birth order and for those expected for birth order and mother's age simultaneously, indicate that the changes in the relationship between these variables were favourable. Even if the specific rates had remained constant, the changes in structure would have led to a drop in infant mortality.

What happens to the expected rates by mother's age is interesting. The slope, which is slightly positive, indicates that the age structure has changed adversely over time, a result of the higher mortality among children of very young mothers. However, the expected rates calculated on the structure by mother's age and birth order together have a more pronounced negative slope than those calculated solely on structure by birth order. This corroborates that the effects are not additive but, on the contrary, that an interaction permits the joint influence of both variables to be more favourable than the sum of their isolated effects.

To quantify the contribution of changes in structure to the decline observed, the slopes for the expected rates were compared with the slope for the observed rates, calculating the ratio between them.

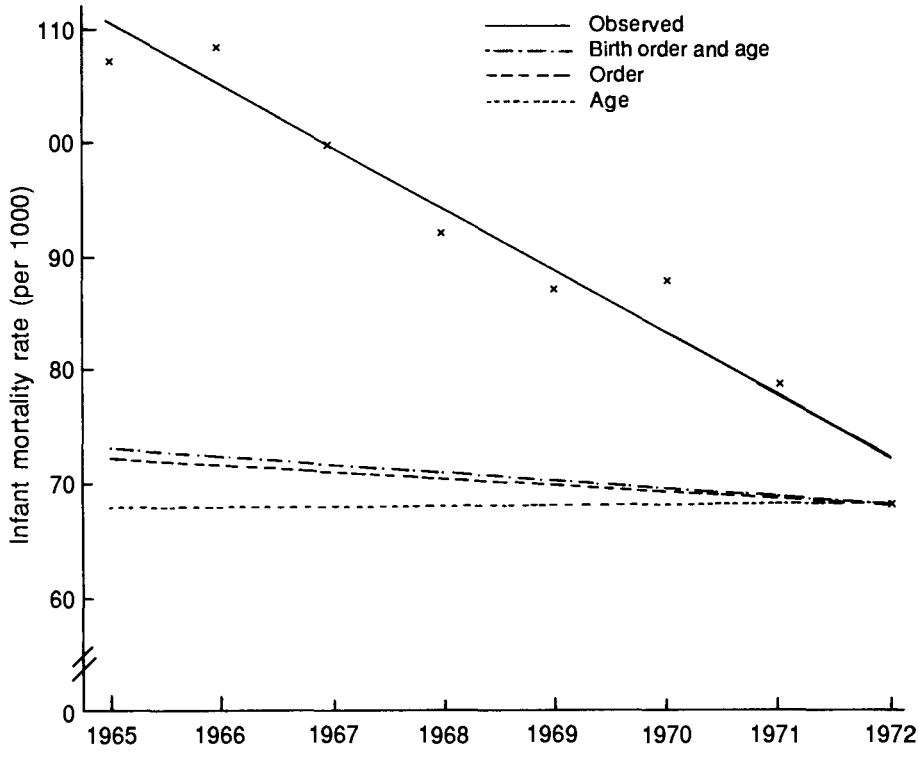

Fig. 11. Lines adjusted to observed and expected infant mortality rates, applying the specific rates for 1972 to the corresponding structures of registered births.

This was done because the trend in the observed rates represents the combined effect of all the factors related to infant mortality. Thus, the ratio between the slope of the expected rates and that of the observed rates will indicate what proportion of the change can be attributed to the factors that were taken into account when calculating the expected rates. This interpretation will be correct only if the effect of the factors considered and that of the set of other factors are additive.

The part played by the different factors in the total decrease, estimated in this way, is:

	slope "bi"	Total contribution (bi/b)
Birth order	-0.6224	0.1114
Mother's age	0.0193	-0.0035
Birth order and mother's age	-0.6986	0.1251
All factors	-5.5849	1.0000

These results indicate that combined changes in structure due to the mother's age and birth order are responsible for 13% of the decline in infant mortality observed from 1965 to 1972. The remaining 87% should be attributed to other factors if these are independent of the ones considered. It is not possible to say, however, that these factors are all alien to changes in fertility. For example, no measurement was made of the effect of lower income sectors gaining

Table 24. Contribution of changes in birth structure from 1972 to 1978 with regard to birth order (O), mother's age (A), mother's level of education (E), and their interactions, to the drop in infant mortality from 74.50 to 40.93, Chile.

Variables	Standardized rate 1972[a] (1)	Difference from the observed rate 1972[b] (2)	Contribution to the drop in infant mortality of the changes in composition for each variable	
			Absolute[c] (3)	Relative[d] (4)
O	71.25	3.25	3.25	9.7
A	74.49	0.01	0.01	0.0
E	68.70	5.80	5.80	17.3
O x A	70.04	4.46	1.20	3.6
O x E	67.22	7.28	-1.77	-5.3
A x E	69.11	5.39	-0.42	-1.3
O x A x E	67.42	7.08	-0.99	-2.9
Total			7.08	21.1

[a] The standardized rate is the infant mortality rate that would have been observed in 1972 if births in that year had had the composition of 1978 with respect to the variables indicated and their combinations.

[b] Difference between the standardized rate (column 1) and 74.50, the rate observed in 1972.

[c] The effect of a change in composition of a variable is equal to the difference between the observed rate in 1972 (74.50) and the standardized rate for the composition of this variable. Example: Effect O = 74.50 - 71.25 = 3.25. The contribution of the interaction due to changes in the overall composition of two variables is equal to the difference (column 2) less the effects of each of the components. Example: Effect O x A = 4.46 - 3.25 - 0.01 = 1.20. The contribution of interaction due to changes in the composition of three variables is equal to the difference (column 2) minus all the single effects and those of the interaction of their components. Example: Effect O x A x E = 7.08 - 3.25 - 0.01 - 5.80 - 1.20 + 1.77 + 0.42 = -0.99. The sum of the single effects and the contribution of the interactions in column 3 is equal to the difference between the rate observed in 1972 and the standardized rate for composition of births with regard to the three variables and corresponds to the change in the rate of infant mortality that can be attributed to the changes in the structure of births with respect to the three variables studied.

[d] These are the values of column 3 in relation to the difference 33.57 between the rates observed in 1972 and 1978.

Table 25. Contribution of change in birth structure and level of mother's education to the decline in mortality among children under 1 month, 1-11 months, and under 1 year from 1972 to 1978 in Chile.

	Attributable percentage reduction		
	1 month	1-11 months	1 year
Order	7.5	10.9	9.7
Age	1.0	-0.5	0.0
Education	12.6	19.8	17.3
Order x age	-1.2	6.1	3.6
Order x education	-3.1	-6.4	-5.3
Age x education	-1.7	-1.0	-1.3
Order x age x education	4.2	-6.8	-2.9
Total	19.3	22.1	21.1

access to the birth control program included in 1964 in the mother and child program of the National Health Service.

Application of a Direct Standardization Method to Chilean Data from 1972 to 1978

A direct standardization method was used to determine the contribution made by changes in birth structure from 1972 to 1978 to the decline in infant mortality in Chile in the same years. The specific 1972 rates for birth order, mother's age, mother's level of education, and combinations of these variables were applied to the birth structure in 1978, which constituted the standard population. The percentage decrease that can be attributed to the effects of the change in structure was determined, considering each major effect and the interactions between them. The procedure is explained for calculations of infant mortality rate in Table 24; results for neonatal, postneonatal, and total infant mortality rates are given in Table 25.

Changes in composition due to mother's level of education have contributed most to the decline, followed by changes in the composition of birth order. Variations in structures by maternal age, however, did not contribute significantly. The single effects and their interactions explain 19-22% of the total drop in the rates; the remainder is caused by other factors, e.g., changes in birth structure due to variables that have not been explored here or health programs, supplementary food programs, or other programs that have reduced the risk of death in infants under 1 year.

The data in Tables 1-6 show that within each cell in the tables, neonatal, postneonatal, and infant mortality decline from 1972 to 1978 for identical categories of birth order, mother's age, and mother's level of education, which must be explained by factors other than changes in birth structure. The same procedure was subsequently used to determine that the change in birth structure in Chile accounted for 29.5% of the drop in infant mortality between 1972 and 1982. Once again, the most important factor was the change in composition with regard to mother's education.

CHAPTER 4: OBJECTIVES FOR FUTURE RESEARCH ON FERTILITY AND INFANT MORTALITY

The ultimate goal of most research on infant mortality is to obtain information that will lead to a reduction in current mortality level. Thus, the spectrum of research objectives ranges from identification of the causes or determinants of infant mortality to evaluation of the success of actions and programs to reduce it.

Within this frame of reference, research on the impact of changes in fertility on infant mortality level could have one or several of the following goals: (1) to identify high fertility as one of the determinants of high infant mortality, (2) to measure or predict the impact of changes in fertility levels on infant mortality, or (3) to investigate the nature of the relationship between fertility and infant mortality.

If research shows that a drop in fertility contributes to a reduction in infant mortality, this would serve as an argument for family planning. This is important in countries where, because of low population density, for example, no justification can be perceived for reducing population growth. The repercussion of this is that couples, especially those from the poorest strata, have no informed access to contraception, a right recognized by the governments of all countries at many international conferences.

Identify High Fertility as a Determinant of Infant Mortality

This objective could be achieved through research showing infant mortality differentials with respect to variables such as birth order, mother's age, or the length of previous birth interval, linked to fertility levels.

Although we have seen that infant mortality patterns related to these variables repeat themselves in all the countries studied, examining them for a single country would be more effective to identify high risk groups or to advise planning births under the most favourable conditions for infant survival.

The same objectives can be attained by showing the direct link that exists between fertility and infant mortality levels over time or in different regions or subdivisions of a country. The limiting factors on establishing causal relations have already been discussed. However, for the lay person in this field, these relations between levels are probably more understandable than more complex reasoning

with regard to mortality differentials and the influence of birth structure on infant mortality levels. Therefore, including this type of analysis is useful in research whose objective is to create a favourable attitude toward family planning. Scientific ethics require that it be stated that common conditioning factors may exist, and showing differentials and their implications for infant mortality levels will also be useful.

Measure or Predict the Impact of Changes in Fertility on Infant Mortality Levels

Studies of the effects of different explanatory variables on some dependent variables have become increasingly frequent as researchers gain access to computers and to multivariate analysis methods. Interpreting the results of these procedures is not always easy, especially when data does not fulfill the assumptions on which the analysis methods are based.

When data are available on differentials with regard to variables related to fertility, and birth structure is known for the different groupings of these variables, methods to standardize rates can be used that may provide guidance on the importance that can be attached to changes in structure within total change.

Extrapolations for the future are arithmetically feasible and can be useful as an argument for family planning. Obviously, if difficulties exist in interpreting events that have already happened, they will be greater still when we wish to predict the future. This is not to invite inaction because of the fear of making mistakes, but rather is a recommendation to exercise caution in interpreting the results of methods that assist in analyzing data, but that do not replace the good judgment of the researcher.

Investigate the Nature of Differentials with Regard to Variables Linked to Fertility

There are, as yet, no conclusive results on the nature of differentials caused by birth order, mother's age, or previous birth interval. Conducting research with this in mind is useful. Separating the effects of economic and social characteristics from those of fertility is essential.

CHAPTER 5: CONCLUSIONS

A decline in fertility will lead to a drop in infant mortality when it involves fewer births separated by short intervals, fewer children born to one woman, and fewer births at either end of the child-bearing period. However, because of the influence of socioeconomic factors on infant mortality level, if births in the highest social strata gradually drop, infant mortality may increase as fertility begins to decrease.

There are indications that infant mortality differentials based on birth order, mother's age, and length of previous birth interval are predominantly biological in origin. Therefore, regulation of fertility would be justified so that women can bear their children under optimal conditions of number, age, and spacing, regardless of the socioeconomic stratum to which they belong. However, research on this subject must continue because the current results are not conclusive.

Both vital statistics and data from surveys on birth histories can be used for these investigations. Another useful source could be information on the previous child collected from mothers who have just given birth. These data share the advantage of vital statistics in making it easy to pinpoint events in time and the advantage of surveys in coming from a single informant. Also, they can provide continuous recording of levels of infant mortality, with a minimum time-lag, if the data are collected at the time a birth is registered in countries where those records are reasonably complete.

Studies of the impact of factors related to high fertility on infant mortality are especially interesting as an argument for implementing family planning in countries where, due to low population densities or for other reasons, it is not perceived to be justified from a demographic viewpoint.

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